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Indian Standard

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सुखाने वाले ड्रायर — विशिष्टि

(पहला पुनरीक्षण)

Desiccant Driers — Specification

(First Revision)

ICS 71.100.45; 27.200; 23.100.60

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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Refrigeration and Air Conditioning Sectional Committee had been approved by the Mechanical Engineering Division Council.

This standard was first published in 1987. The Committee responsible to upgrade this standard focused upon the current technological advancement in design, construction methodologies and testing.

The major changes incorporated in the standard are as follows:

     a) The standard is made more comprehensive than the previous version dated 1987;

     b) New terminology more specific to liquid line filter driers is included;

     c) Refrigeration component general requirements are referred from IS 16678/ISO 5149 series;

     d) Standard requirement for specifying the ratings are added;

     e) External appearance, corrosion, and pre-adsorption requirements added;

     f) Acid capacity requirements and test methods added; and

     g) Test procedures and setup are added in annexures.

This standard recognizes the unique nature of driers and filter driers for refrigeration systems or heat pumps and is intended to address specific needs of the refrigeration and heat pump industry. This standard should be read in conjunction with various parts of IS 16678/ISO 5149.

When the text of this standard modifies or supplements a clause with various parts of IS 16678/ISO 5149, then this standard should prevail. Where this standard does not modify or supplement a clause, the requirements of various parts of IS 16678/ISO 5149 should prevail.

The composition of the Committee responsible for the formulation of this standard is given in Annex K.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

DESICCANT DRIERS — SPECIFICATION

(First Revision)

1 SCOPE

1.1 This Indian Standard specifies general requirements, performance rating, testing and documentation of driers and filter driers manufactured using solid desiccant designed for use in the liquid line of refrigeration systems employing HFC and HCFC refrigerants conforming to IS 16656/ISO 817 having atmospheric boiling point lower than 20 °C.

1.2 This Indian Standard applies to driers and filter driers with threaded, welded or brazed connectors as a part of the first circumferential joint connecting piping or other elements of refrigeration system.

1.3 This Indian Standard applies to all driers and filter driers with an internal pressure down to – 100 kPa (– 1 bar), to account for the evacuation prior to charging with refrigerant.

1.4 This Indian Standard applies both mechanical and thermal loading conditions as defined in IS 16678/ISO 5149 (Part 1 to 4) applicable for refrigeration systems. Products designed to this standard should have maximum design temperature not exceeding 200 °C and a maximum pressure not exceeding 16 000 kPa (160 bar). Outside of this limit it is important that IS 2825 is to be used for design, construction and inspection of pressure vessels. The products complying with this Indian Standard used in refrigeration systems and heat pumps comply with all other relevant clauses from IS 16678/IS 5149 (Parts 1 to 4).

1.5 This Indian Standard applies to pressure vessels where the main pressure bearing parts are manufactured from metallic ductile materials.

1.6 The subject of filtration is considered separate and distinct from the consideration of this standard. Therefore, the performance and rating of a drier is on the premise of a clean drier and clean refrigerant.

1.7 Driers incorporating a monolithic core as the desiccant are also covered in the scope of this standard.

1.8 The products not covered under this standard are:

a) Vessels of riveted construction; and

b) Multilayered, hydro formed or pre-stressed vessels.

2 REFERENCES

The following standards contain provisions, which through reference in this text constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No./ISO No.	Title
460 (Part 1) : 2020	Test sieves — Specification Part 1 Wire cloth test sieves (*fourth revision*)
460 (Part 2) : 2020	Test sieves — Specification Part 2 Perforated plate test sieves (*fourth revision*)
ISO 2409 : 2020	Paints and varnishes — Cross-cut test
2825 : 1969	Code for unfired pressure vessels
3401 : 1992	Silica gel — Specification (*third revision*)
3615 : 2020	Glossary of terms used in refrigeration and air conditioning (*second revision*)
ISO 4628-2 : 2016	Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 2: Assessment of degree of blistering
ISO 4628-3 : 2016	Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 3: Assessment of degree of rusting

IS No./ISO No.	Title	IS No./ISO No.	Title

ISO 4628-4 : 2016 — Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 4: Assessment of degree of cracking

ISO 4628-5 : 2016 — Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 5: Assessment of degree of flaking

ISO 6270-1 : 2017 — Paints and varnishes — Determination of resistance to humidity — Part 1: Condensation (single-sided exposure)

ISO 9227 : 2017 — Corrosion tests in artificial atmospheres — Salt spray tests

ISO 12103-1 : 2016 — Road vehicles — Test contaminants for filter evaluation — Part 1: Arizona test dust

ISO 12944-6 : 2018 — Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 6: Laboratory performance test methods

ISO 14903 : 2017 — Refrigerating systems and heat pumps — Qualification of tightness of components and joints

IS 16656 : 2017/ ISO 817 : 2014 — Refrigerants — Designation and safety classification

IS 16678 (Parts 1 to 4) : 2018/ISO 5149 (1 to 4) : 2014 — 'Refrigerating systems and heat pumps — Safety and environmental requirements':

Part 1 Definitions, classification and selection criteria

Part 2 Design, construction, testing, marking and documentation

Part 3 Installation site

Part 4 Operation, maintenance, repair and recovery

IS/ISO 17584 : 2005 — Refrigerant properties

3 TERMINOLOGY

For the purpose of this standard, the terms given in IS 3615, IS 16678/ISO 5159 (Parts 1 to 4) and the following shall apply.

3.1 Attribution Index (ratio) of Desiccant Driers

Attribution Index =

$$\frac{\text{Weight of dry 100 mesh fines}}{\text{Weight of original sample}} \times 100$$

3.2 Drier — A drier is a device containing desiccants whose primary purpose is collecting and holding moisture and/or acid that may have entered/developed in the system.

3.3 Filter — A component used in refrigeration and air-conditioning systems for removing and collecting solid contaminants existing in the refrigerant flow.

3.4 Filter Drier — A component used in refrigeration and air-conditioning system for the primary purpose of collecting and holding solid contaminants, moisture and/or acid that may have entered the system.

3.5 Desiccant — A solid that will collect and hold water while being itself totally insoluble in the refrigerant medium comprising the refrigerant, oil and water.

3.6 Equilibrium Point Dryness (EPD) — The lowest possible water content of a liquid refrigerants attainable by a specific drier at a specific temperature, after an equilibrium has been reached between the water in the refrigerant and that in the drier. EPD is calculated by mass and expressed in parts per million (ppm).

3.7 Pressure Drop — The pressure difference between the inlet and the outlet of a liquid line drier, including its connections.

3.8 Water Capacity — The amount of water which a drier will collect and hold at each rating conditions and still maintain equilibrium a specified temperature and specified EPD level in a refrigerant. It may be expressed in drops or grams, 20 drops being considered equivalent to one gram.

3.9 Refrigerant Flow Capacity — The refrigerating capacity for flow of liquid refrigerant at specified condition which the liquid line drier pass and not exceed the specified pressure drop.

3.10 Acid Capacity — Mass of the acid dissolved in the refrigerant that can be adsorbed by 100 g of filter

element when in full capacity and equilibrium is reached between the filter drier and the refrigerant that contains 3 percent (volume) of refrigeration oil.

3.11 Lumped Core — Molecular sieve granules bonded together and molded into variety of shapes and sizes.

3.12 Granular Molecular sieve — Also known as loose beads is 100 percent molecular sieve in granular form/loose beads.

3.13 Contaminant Capacity (M_c) —The mass of test contaminant that is retained by the filter under test, expressed in grams.

3.14 Containment Loading (M_t) — The mass of test contaminant that is added to the test apparatus, expressed in grams.

3.15 Overall Filter Efficiency (E_f) — The ratio of contaminant capacity to the contaminant loading, expressed as a percent.

3.16 Pressure Drop — The pressure difference between the inlet and the outlet of a liquid line filter, including its connections.

3.17 End-point Pressure Drop — The specified pressure drop for the rated filter at which the contaminant loading is determined.

3.18 Published Rating — A statement of the assigned values of those performance characteristics, under stated rating conditions, by which a liquid line filter may be chosen to fit its application. These values apply to all liquid line filters of like nominal size and type (identification) produced by the same manufacturer. The term published rating includes the rating of all performance characteristics shown on the component or published in specifications, advertising or other literature controlled by the manufacturer, at stated rating conditions.

3.19 Application Rating — A rating based on tests performed at application rating conditions (other than standard rating conditions).

3.20 Standard Rating — A rating based on tests performed at standard rating conditions.

3.21 Rating Conditions — Any set of operating conditions under which a single level of performance results and which causes only that level of performance to occur.

3.22 Standard Rating Conditions — Rating Conditions used as the basis of comparison for performance characteristics.

3.23 Test Flow Rate — The mass flow rate of clean test fluid that is specified for the filter under test.

3.24 Acid Capacity — Acid capacity is the grams of oleic acid removed per 100 grams of adsorbent when in equilibrium with a specified concentration of oleic acid dissolved in refrigerant containing 3 percent oil by volume. When a commercial filter drier used in the test, then the acid capacity is the grams of oleic acid removed by the specified drier type, under the above conditions.

3.25 Maximum Allowable Pressure/Maximum Working Pressure (MWP) — The maximum working temperature shall be selected high enough for all operating and stand by conditions according the highest-pressure refrigerant that the filter will be operating. For system working on high temperatures areas or tropical is recommended to consider a temperature minimum of 70 °C.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

a) IEC Electropedia: http://www.electropedia.org

b) ISO Online: http: //www.iso.org/obp

4 PRODUCT REQUIREMENTS

4.1 General Requirements

Filters shall be manufactured in accordance with the provisions of this standard and comply with the specifications as a qualifying requirement based on the technical documentations that is approved through prescribed procedures herewith.

4.2 Classification

4.2.1 Structurally, filters are classified into two types: Hermetic (Integral) and Semi-hermetic (Detachable).

4.2.2 Based on connection between the filter and the system they are additionally classified into three types: Flanged, Welded/Brazed, and Threaded.

4.3 Desiccant Type

In most driers, the desiccant employed is either silica gel, molecular sieve or monolithic core.

4.3.1 *Silica Gel*

Silica gel is a synthetically produced silicon dioxide (S_iO_2) having an extremely porous structure. While generally it may conform to IS 3401 but for specific use in desiccant driers, it shall meet the requirments given in Annex A.

4.3.2 *Molecular Sieve*

Molecular sieve is an synthetic zeolite for use in refrigeration system. The type 3A°/4A° used would adsorb moisture and allow hydro carbon molecules to pass through. Requirements for molecular sieve suitable for use in desiccant driers are given in Annex B.

4.3.3 *Core Type Desiccants*

These are of special design and construction consisting bonded molecular sieve and are considered acceptable if the desiccant drier fulfils the requirments of this standard.

4.4 Materials

4.4.1 Pressure bearing parts to be made of any suitable material compatible with the system of refrigerant. The thickness of material used shall be adequate and the method of manufacture including brazing/welding, etc., shall be sound and free from defects. The drier shall meet the strength and endurance requirements as specified in **4.5**.

4.4.2 Additionally, **4.3** of IS 16678 (Part 2)/ISO 5149-2 requirements apply.

4.4.3 It is permitted to use non-metallic materials for non-pressure bearing parts (for example, gaskets, coatings, insulating materials, sight glasses) provided they are compatible with the other materials, refrigerants and lubricants present.

4.5 Tightness or Leak Test

4.5.1 Filter driers must be tested 100 percent for tightness/leak.

4.5.2 The drier shall not show any leakage when it is tested under alcohol/water bath for minimum 60 seconds at maximum working pressure (MWP). Manufacturer must ensure that the liquid from the bath must not enter the product. Use non-flammable gases for test to ensure safety.

4.5.3 Alternatively, filter driers shall be tested with detection equipment with a sensitivity of 3 g/yr of refrigerant or better, under a pressure of at least $0.25 \times$ MWP. Acceptance criteria is that no leak shall be detected. Additional requirements of **4.4.3** of IS 16678 (Part 2)/ISO 5149-2 as per the procedure specified in ISO 14903 is applicable.

4.5.4 Either **4.5.2** or **4.5.3** to be performed for tightness or leak test.

4.6 Strength Pressure Test

4.6.1 Strength pressure tested at $1.43 \times$ MWP for 60 s. Test media is air or non-hazardous gases like nitrogen, helium, etc. Additional requirements from **4.4.2** of IS 16678 (Part 2)/ISO 5149-2 is applicable.

4.6.2 The acceptance criteria is that permanent deformation shall not result from these tests.

4.7 Type Approval Test

4.7.1 The components can be type-approved by testing at $3 \times$ MWP for minimum 60 s or by testing according

to the fatigue test. Additional requirements from **4.4.2.3** of IS 16678 (Part 2)/ISO 5149-2 is applicable.

4.7.2 The acceptance criteria is that the component shall not have any rupture as a resultant of test.

4.8 Fatigue Test

4.8.1 As an alternative to the pressure test as mentioned above, the components shall be subjected to a strength-pressure test at $2 \times$ MWP provided they comply with the fatigue test as described below.

4.8.2 Three test samples shall be filled with fluid and shall be connected to a pressure-driving source. The pressure shall be raised and lowered between the upper and lower cyclic values at a rate specified by the manufacturer for a total number of 250 000 cycles. The entire specified pressure excursion shall occur during each cycle.

4.8.3 The following test pressures shall be applied: For the first cycle MWP shall be applied, for test cycles upper pressure value shall not be less than $0.7 \times$ MWP and the lower-pressure value shall not be greater than $0.2 \times$ MWP with a frequency of 10-60 cycles/minute. Full specified upper and lower pressure values are maintained for at least 0.1s. For the final test cycle the test pressure shall be increased to $1.43 \times$ MWP. Additional requirements from **4.4.2.4** of IS 16678 (Part 2)/ISO 5149-2 is applicable.

4.8.4 The acceptance criteria is that the component shall not rupture,burst, or leak after completion of this test. The strength pressure test of $2 \times$ MWP must be performed on 3 samples, other than the samples used for fatigue test.

4.9 Attribution Index

The attribution index of the desiccant as loose beads, determined according to the method described in Annex H, shall not be more than 0.25 percent.

4.10 Direction of Flow

The intended direction of flow of refrigerant shall be clearly marked on the body of the drier.

4.11 External Appearance

4.11.1 Filter drier surface shall be clean, free of oil, dust or other impurities. Weld zones shall be free of pores, cracks, pin holes or slags and splatters over the body.

4.11.2 Surface coating and plating shall be smooth and free of blistering, wrinkles, flaking and uneven coating. Final product shall conform to Class C3 high according to ISO 12944-6.

4.11.3 Inner wall of components shall be clean and free of oxidation or corrosion.

4.11.4 Cross cut and water condensation requirements shown in Table 1.

Table 1 Cross Cut and Water Condensation Requirements

(*Clause* 4.11.4)

Sl No.	Assessment Method	Description	Requirement
(1)	(2)	(3)	(4)
i)	ISO 2409 [1]	Cross-cut test	Classification 0 or 1
ii)	ISO 6270-1	Water condensation	After 240 h comply requirement of ISO 2409 and ISO 4628-2 to 5

[1] This assessment shall be performed on fresh samples (before any artificial ageing) according to ISO 6270-1.

4.12 Corrosion Resistance

4.12.1 Products to comply with corrosion resistance requirements against the assessment method and acceptance criteria shown in Table 2.

Table 2 Corrosion Resistance

(*Clause* 4.12.1)

Sl No.	Assessment Method	Description	Requirement
(1)	(2)	(3)	(4)
i)	ISO 9227	Artificial Ageing	After 480 h, corrosion of the substrate from the scratch shall not exceed 1 mm when calculated using equation in Annex A of ISO 12944-6. Areas where paint layer is not damaged by the scribe as well as when the ageing is performed on samples without scribe shall comply requirements of ISO 4628-2 to ISO 4628-5. Neutral salt spray test only to be considered.
ii)	ISO 4628-2 [2]	Blistering	0 (S0)
iii)	ISO 4628-3 [2]	Rusting	Ri 0
iv)	ISO 4628-4 [2]	Cracking	0 (S0)
v)	ISO 4628-5 [2]	Flaking	0 (S0)

[2] Visual assesments shall be according to ISO 9227 and ISO 6270-1.

4.13 Stress Corrosion Cracking (SCC)

Refer Annex G of IS 16678 (Part 2)/ISO 5149-2 for guidance on stress corrosion cracking (SCC).

5 PERFORMANCE REQUIREMENTS

5.1 Refrigerant Flow Capacity

5.1.1 *Principles of Flow Capacity Testing*

The purpose of this test is to determine accurately the weight rate of flow when a specified refrigerant is flowing through the drier at a specified pressure drop. The test is run with a clean refrigerant with a new uncontaminated filter drier.

5.1.2 It may be noted that in actual use, the flow capacity may be less, depending on the degree of contamination. Performing such test on a conventional refrigerating system involved numerous experimental difficulties, so 'Liquid pumped test loops' as described in Annex C may be used.

5.1.3 Applicable for liquid-line driers for use in refrigerant systems employing the halocarbon refrigerants having atmospheric boiling point below 20 °C (68 °F).

Exclusion — Performance ratings does not apply to liquid anti-freeze solution desiccants or driers used in the suction line or low side of refrigeration and air-conditioning systems.

5.1.4 *Rating Requirements*

Refrigerant flow capacity shall be based on the refrigerant flow rate through liquid-line driers with in the specified pressure drop of 6.9 kPa and the refrigerant flow rate per kilowatt of refrigeration at 30 °C liquid and – 15 °C saturated vapour.

5.1.5 The refrigerant flow capacity rating is obtained by dividing the refrigerant flow rate expressed in kg/s at a pressure drop of 6.9 kPa by the flow rate per refrigerating capacity in kW expressed in (kg/s)/kW. For details refer Annex C. Examples shown in Table 3 for various refrigerants.

Table 3 Flow Rate per kW of Refrigeration at 30 °C Liquid and – 15 °C Saturated Vapour

(*Clause* 5.1.5)

Sl No.	Refrigerant Number	Unit Refrigerant Flow Capacity (kg/s)/kW
(1)	(2)	(3)
i)	R 22	0.006 4
ii)	R 134a	0.006 7
iii)	R 404A	0.008 8
iv)	R 407C	0.006 4
v)	R 410A	0.006 0
vi)	R 507A	0.009 0

5.1.6 *Tolerance*

To comply with this standard, measured test results shall not be less than 90 percent of published ratings for refrigerant flow capacity and water capacity.

5.1.7 *Minimum Data Required*

As a minimum, published ratings shall include all standard ratings.

5.1.8 *Published Ratings*

Refrigerant flow capacity ratings for standard temperatures of 24 °C and 52 °C shall be published and expressed in kW.

5.1.9 *"As Received" Ratings*

Published data shall be further qualified by specifying whether a liquid-line drier will meet the published capacity ratings in an "As Received" condition. If further activation of the liquid-line drier is necessary, published data shall outline the activation procedure.

5.1.10 *Testing Procedure*

Filter driers shall be tested in accordance with the procedure outlined in Annex C.

5.2 Water Capacity

5.2.1 *Principle* —The test method involves adding a known amount of water to the test drier, passing refrigerant through this drier at a very slow rate while keeping the drier at a fixed temperature, then determining EPD of the effluent refrigerant as per method indicated in Annex D.

> NOTE — It has been demonstrated that at the slow flow rate specified, equilibrium conditions are achieved.

5.2.2 To make a comprehensive evaluation of a drier, it is necessary to repeat the above procedure with various amounts of water added to each of several driers, and various fixed temperatures. This permits the plotting of isotherm curves of EPD versus water capacity. This entire procedure shall be repeated with each of the different refrigerants for which it is desired to evaluate the drier.

Table 4 Standard Rating Conditions

(*Clause* 5.2.4)

Sl No.	Nominal Hermetic Filter Size cm³(in³)	Nominal Connection Size mm (in)	Flow Rate kg/s	End-Point Pressure Drop (kPa)
(1)	(2)	(3)	(4)	(5)
i)	< 49 (3)	6 (¼)	0.05	34
ii)	49 ~ 246 (3 ~ 15)	10 (3/8)	0.11	34
iii)	98 ~ 639 (16 ~ 39)	12 (½)	0.21	34
iv)	655 ~ 1229 (40 ~ 75)	16 (5/8)	0.32	34

5.2.3 Applicable for liquid-line driers for use in refrigerant systems employing the halocarbon refrigerants.

5.2.4 *Rating Requirements*

5.2.4.1 Liquid-line driers shall be rated by their water capacity in drops and shall include their ratings at the standard rating conditions in Table 4.

5.2.4.2 Water capacity ratings shall be determined in accordance with the rating procedure outlined in **D-9.3** and statistical method outlined in **D-9**.

5.2.5 *Tolerance*

To comply with this standard, measured test results shall not be less than 90 percent of published ratings for water capacity.

5.2.6 *Minimum Data Required*

As a minimum, published ratings shall include all standard ratings.

5.2.7 *Published Ratings*

Water capacity ratings for standard temperatures of 24 °C and 52 °C shall be published and expressed in drops.

5.2.8 *As received ratings* — *See* **5.1.9**.

5.2.9 *Testing procedure*

Filter driers shall be tested in accordance with the procedure outlines in Annex D.

5.3 Overall Filter Efficiency and Contaminant Capacity

5.3.1 *Scope*

This clause applies to hermetic liquid line filters designed for use in the liquid line of all types of refrigeration and air-conditioning systems employing the following refrigerants: R-22, R-134a, R-290, R-404A, R-407A, R- 407C, R-410A, R-507A, R-600a, and R-744 as defined in IS 16656/ISO 817. This clause provides a means of determining the overall filter efficiency and contaminant capacity of a liquid line filter at specified conditions.

5.3.2 *Exclusions*

This standard does not apply to filters used in the suction line or low-pressure side of refrigeration and air-conditioning systems.

5.3.3 *Testing Procedure*

Liquid line filter ratings shall be based on tests conducted in accordance with the procedure outlined in Annex D.

5.4 Rating Requirements

Liquid line filters shall be rated by their overall filter efficiency and contaminant capacity and shall include their ratings at the standard rating conditions in Table 1. All tests shall be conducted with the test fluid at a single temperature within the range of 24 °C to 27 °C.

5.4.1 Overall filter efficiency and contaminant capacity shall be determined in accordance with the procedures outlined in Annex E.

5.4.2 Statistical procedure applied to the results from testing sets of samples of production liquid line filters

to establish a rating which will be equaled or exceeded by 90 percent of those produced.

5.4.3 When several determinations of overall filter efficiency and contaminant capacity of a single model liquid line filter are made by the procedure according to Annex E, a series of values will be obtained because of manufacturing variations. The average of these results is more reliable than any single result. This average also becomes more reliable as more values are used in calculating the average.

5.4.4 In order to compensate for these testing and manufacturing variations, a statistical procedure is available for arriving at a rating that will guarantee any percent compliance desired.

5.4.5 This rating procedure is a statistical analysis of results obtained from tests on a group of six liquid line filters, and the rating obtained by this procedure will be such that the average overall filter efficiency and contaminant capacity of duplicate tests on any set of six liquid line filter driers will equal or exceed the rating in 90 percent of all cases.

5.4.6 For each of the liquid line filters tested, calculate the average, minimum and maximum pressure drop for each addition of contaminant. The results are then plotted on a linear graph with the contaminant added on the X-axis and the pressure drop on the Y-axis. Three curves are constructed, one for the minimum values, the average values and the maximum values. A horizontal line is drawn from the end point pressure through the average curve. A vertical line is then drawn from the point of intersection to the horizontal axis. (Fig. 1).

Determine the average Overall Filter Efficiency (OE_f) and Overall Filter Mass Capacity retention (OM_c):

Individual filter calculations:

$$Ef = (M_t - M_{cf})/M_t * 100$$
$$M_c = (M_t \cdot E_f)/100$$

E_f = Filter efficiency,

M_c = Contaminant mass capture in filter at 34 kPa,

M_t = Contaminant mass added to the filter under test, and

M_{cf} = Contaminant mass capture on the cleanup filter.

For the rating the test results of at least 6 pieces of the same type are used. The calculation needed for the rating are:

$$OE_f = E_{fa} - 0.36 \times r$$
$$OM_c = M_{ca} \times OE_f$$

where

OE_f = Overall rate efficiency,

E_{fa} = Average filter efficiency of the tested filters,

R = max (E_f)-min (E_f) of the tested filters,

OM_c = Overall contaminant mass for rating, and

M_{ca} = Average mass capture in the tested filters at 34 kPa.

5.4.7 When liquid line filters are tested, statistically at least 90 percent of averages of sets of six liquid line filters, will equal or exceed the rating.

5.4.8 *Tolerances*

To comply with the requirements of this clause, measured test results shall not be less than 90 percent of published ratings for overall filter efficiency and contaminant capacity.
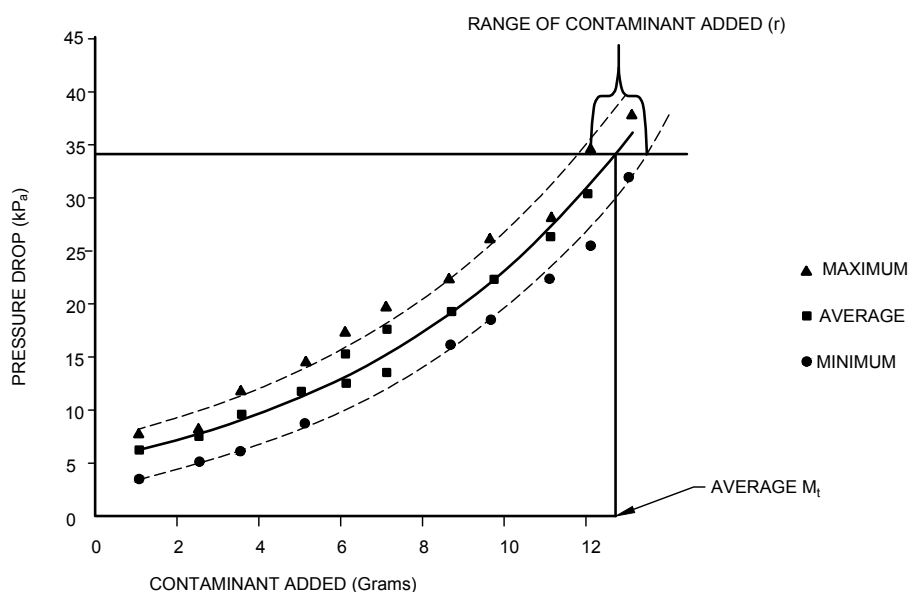

Fig. 1 Pressure Drop vs Contaminant Added

5.4.9 *Minimum Data Requirements for Published Ratings*

As a minimum, published ratings shall include all standard ratings. Wherever application ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

5.4.10 *Published Ratings*

Published ratings shall include the following:

a) Overall Filter Efficiency, Percent (OE_f); and
b) Contaminant Capacity, g (OM_c).

5.5 Acid Capacity (Optional)

5.5.1 Filters should have acid removal data published, and the amount of acid removal actually measured through random sampling and testing shall not be less than 90 percent of the nominal value.

5.5.2 The acid capacity of a filter drier be published as the grams of acid removed by a specific commercial filter drier, or as the acid removed per 100 g of adsorbent. In either case the test value corresponds to a given equilibrium acid number in the oil remaining.

5.5.3 A guideline for the test method is provided in Annex F.

5.5.4 The test method may be used to compare the acid capacity of several different filter driers of different adsorbents, when compared at the same equilibrium acid number value.

5.5.5 The method can also be used to obtain a complete equilibrium adsorption curve for a particular drier. Such a curve would involve a series of test points plotting acid capacity of the desiccant versus acid number in the remaining oil.

5.5.6 If the acid capacity of a given drier or adsorbent is desired at a specified level of acid number in the oil, then test points shall be obtained above and below the specified acid number value. A line drawn between these two points will permit graphical interpolation to obtain the acid capacity at the specified acid number value. Satisfactory accuracy will be obtained with the above procedure, if the test points above and below the final selected value are within 10 percent of the acid capacity of the final selected value.

5.6 Pre-Adsorption

5.6.1 Filter driers shall have less than 3 percent moisture of the total weight of desiccant content.

5.6.2 The filter drier must be suitably protected to ensure the requirement stated in **5.4.1** till the installation.

5.6.3 Specific instructions to protect the filter drier from being contaminated shall be published by the manufacturer.

5.6.4 A guideline to test methods are provided in Annex G.

6 INSPECTION, MARKING AND PACKING

6.1 Inspection and Testing

6.1.1 In order to ensure that filter driers are in compliance with this standards, they shall be subjected to inspection and testing in accordance with **4** for type test and **5** for routine test.

6.2 Marking, Packing and Storage

6.2.1 A nameplate shall be fixed to a conspicuous position of the filter. The nameplate shall indicate the following information:

a) Name of manufacturer;
b) Product model and name;
c) Nominal capacity;
d) Temperature and pressure range; and
e) Date of manufacturing (Year/Week/Shift of manufacturing).

6.2.2 The filter shall be marked with arrows indicating the direction of medium flow.

6.2.3 When leaving the factory, filters shall have protective measures and be sealed against dust, moisture and dampness to ensure cleanliness and protection from being contaminated.

6.2.4 The filter shall be stored in a clean, dry and ventilated indoor space where there are no air-borne harmful substances that may corrode the filter and protected from aggressive environment affecting product function/performance until installation at site.

6.2.5 Responsibility of environmental factors impacting product physically and or functionally lies with the person/organization handling the product.

7 BIS CERTIFICATION MARKING

The product conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standard Act*, 2016 and the Rules and Regulations framed thereunder, and the product may be marked with the Standard Mark.

ANNEX A

(*Clause* 4.3.1)

REQUIREMETS OF SILICA GEL FOR USE INDESICCANT DRIERS

(*Informative*)

A-1 CHEMICAL COMPOSITION

a) SiO_2 95 – 100 percent.

b) Al_2O_3 0 – 5 percent.

c) Impurities   0.5 percent, *max.*

A-2 PROPERTIES

A-2.1 Shooting Weight — Not less than 0.70 kg/l (dry desiccant).

A-2.2 Shaking Weight — 0.83 kg/l, *max* (dry desiccant).

A-2.3 Granular Shape — Minimum 53 percent of the granules shall be whole. A pearl is considered whole when there are no scratches in the surface and when it has retained 75 percent of its original size.

A-2.4 Sieve Sizes Used with Driers

A-2.4.1 The test sieves shall confirm to IS 460 (Part 1) and IS 460 (Part 2).

A-2.4.2 The details of mesh sizes are as under:

a) 150 mesh with 0.5 mm perforated plate is used on outlet side in pencil type driers used in refrigerators, and

b) 150 mesh along with 80 mesh on inlet side along with 1mm perforated plate is used in industrial air-conditioning with silica gel and molecular sieves.

A-2.5 Size of Granules

The following result is required of sieve analysis (regarding sieve sizes, *see* **A-2.4**):

a) On sieve No. 3 : 0.2 percent, *max* shall remain by weight;

b) On sieve No. 6 : 60 percent, *max* shall remain by weight;

c) On sieve No. 10 : 98.8 percent, *min* shall remain by weight; and

d) On sieve No. 18 : 99.8 percent, *min* shall remain by weight.

A-2.6 Compression Strength — The compression strength of the whole fully saturated granules shall correspond to the following values:

a) For 50 percent of the granules: 10 kg, *min*;

b) For 99 percent of the granules: 1 kg, *min*.

A-2.7 Wearability — 0.2 percent, *max* by weight through sieve No. 30.

A-2.8 Water Content — 0.5 percent, *max* by weight.

A-2.9 Absorption Capacity at Equilibrium with Moisture — 33 percent, minimum by weight at 25 ± 1 °C and 80 percent relative humidity.

A-3 PACKING

A-3.1 Shall be supplied in plumbed moisture-proof containers.

A-3.2 Normally, a slight vacuum is provided in the sealed container.

ANNEX B

(*Clause* 4.3.2)

REQUIREMETS OF MOLECULAR SIEVE FOR USE IN DESICCANT DRIERS

(*Informative*)

B-1 PROPERTIES

B-1.1 Shooting Weight — 0.720 kg/l, *max* (dry desiccant).

B-1.2 Shaking Weight — 0.850 kg/l, *max* (dry desiccant).

B-1.3 Granular Form — The granules shall be approximately spherical and shall not have sharp edges. The granules shall not contain more than 3 percent by weight, of fragments.

B-1.4 Size of Granules —The balls shall correspond to 4 × 8 mesh (regarding sieve size, *see* **A-2.4**).

a) Through sieve No. 4: 100 percent, shall fall through;

b) On sieve No. 8: 95 percent, *min* shall remain;

c) On sieve No. 20: 99 percent, *min* shall remain; and

d) Through sieve No. 100: 0.05 percent, *max* shall fall through.

B-1.5 Compression Strength The compression strength of the moisture saturated desiccant balls shall correspond to the following values:

a) For 99.5 percent of the balls: 1.5 kg, *min*;

b) For 84 percent of the balls: 5.0 kg, *min*;

c) For 50 percent of the balls: 7.3 kg, *min*.

The values stated are applicable for a normal (Gaussian) distribution.

B-1.6 Wearability — The wear ability of the desiccant shall be 3.0 percent, *max* by weight.

B-1.7 Water Content — The water content shall not exceed 1.5 percent by weight.

B-1.8 Absorption Capacity — At a water vapour partial pressure of 17.5 mm Hg at 22 °C to 30 °C the desiccant shall be able to absorb not less than 16.0 percent by weight, of water.

B-1.9 Resistance to Oil-Refrigerant Mixtures — While placed in mixtures of refrigerator oil and refrigerants at temperature between boiling point for pure refrigerant and + 90 °C, the desiccant shall not go below the values specified.

B-2 PACKING

B-2.1 Shall be supplied in plumbed, moisture-proof container.

B-2.2 Normally a slight vacuum is provided in the sealed container.

ANNEX C

(*Clauses* 5.1.2, 5.1.5 *and* 5.1.10)

REFRIGERANT FLOW CAPACITY

(*Normative*)

C-1 PURPOSE

The purpose of this annex is to prescribe test methods for determining flow capacity and performance characteristics of liquid line refrigerant driers applying desiccant.

C-2 GENERAL

C-2.1 This annex defines method of testing only.

C-2.2 The method tries to establish the best possible performance evaluation, however following factors affect the performance further, which are not considered in here:

a) The physical characteristics of the desiccants;

b) The chemical characteristics of the desiccants;

c) The mechanism of water adsorption;

d) The filtration ability of a drier;

e) The acid adsorption of a drier;

f) The performance of a drier in other than a liquid line;

g) The speed of drying;

h) The drier water capacity needed in relation to the size of a system, potential freeze-up problems, or potential chemical activity problems; and

j) The effect of oil on a drier's performance.

C-3 PRINCIPLES OF FLOW CAPACITY TESTING

The purpose of this test is to accurately determine mass flow rate when a specified refrigerant is flowing through the drier at a specified pressure drop. The test is performed with clean refrigerant and a new, uncontaminated drier. It may be noted that in actual use the flow capacity may be less, depending on the degree of contamination. Performing such a test on a refrigerating system involves numerous experimental difficulties; therefore, liquid-pumped test loops, such as diagrammed in Fig. 2, have been developed.

C-4 EQUIPMENT

The apparatus required for flow capacity testing is shown in Fig 2. The requirements and limitations of the equipment are described herein.

C- 4.1 Lines and Arrangement

The line sizes used through the system may be any convenient size so that the capacity of the system can be varied over a wide range of flow rates to accommodate testing of driers of many sizes. However, the lines connected to the drier shall be the same size as the test drier fittings and should be straight for a distance of at least 15 times inside tube diameters upstream and 15 times inside tube diameters downstream of the test drier.
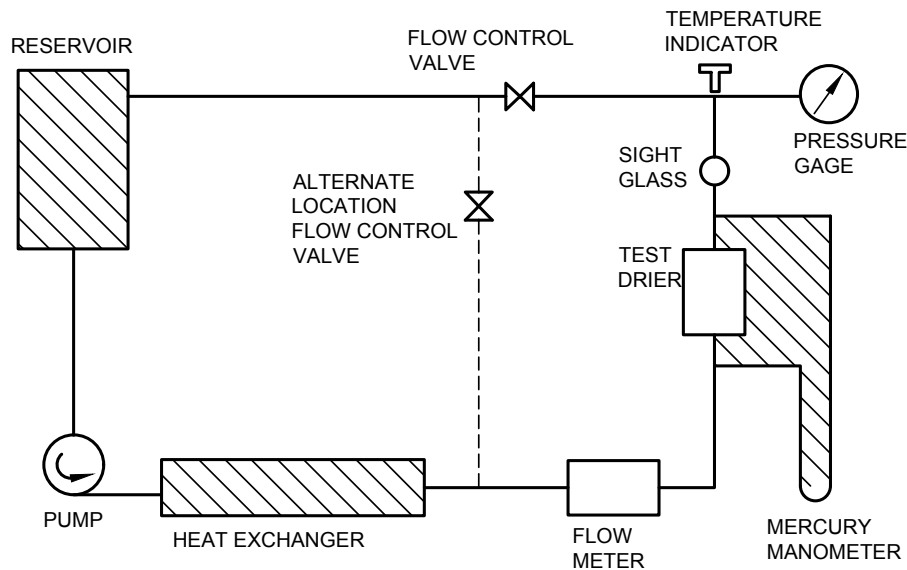
Fig. 2 Schematic Diagram — Liquid Pump Test Loop

C-4.2 Pump

The pump shall be such that it will produce steady-state, non-pulsing flow in an amount sufficient to maintain at least 20 kPa (3 psi) pressure drop across the drier being tested or sufficient to meet the requirements of **C-7**.

C-4.3 Heat Exchanger

A heat exchanger may be required to maintain steady refrigerant temperature in the range of 25 °C to 45 °C (77 °F to 113 °F).

C-4.4 Flow Meter

Any generally accepted type of flow meter may be used, such as an orifice meter, venturi meter, rotameter, or positive displacement meter, provided that the meter is of such construction and installed in such a way that it does not create undue turbulence or disturb the steady-state flow in the system. Because the meter used is a very vital part of the apparatus, it shall be calibrated to ensure that any error in indicated flow is less than 5 percent.

C-4.5 Manometer

The pressure drop across the test drier shall be measured by a mercury manometer or other means with a maximum error of 0.3 kPa (0.05 psi) or less. The manometer reading shall be corrected for the effect of the refrigerant column on top of the mercury. The pressure taps shall be located at least 2 times inside tube diameters upstream of the drier and 10 times inside tube diameters downstream of the drier. Burr-free holes with a 2 mm (0.06 in.) diameter shall be used for pressure taps, except in 6.4 mm (0.25 in.) or less diameter tube where 1 mm (0.03 in.) diameter holes shall be used.

C-4.6 Sight Glass

A sight glass shall be installed on the downstream side of the test drier so a visual check can be made to ensure that no flash gas is present in the refrigerant.

C-4.7 Temperature Indicator

An indicator shall be installed to measure the refrigerant temperature at the downstream side of the test drier and pressure tap. The type of instrument, its calibration, and its installation shall be such as to ensure that any error in indicated temperature is less than 2 °C (3 °F).

C-4.8 Flow Control Valve

Means shall be provided to manually adjust the flow rate through the test drier so that pressure drop can be set at various values in the range from 50 percent to 150 percent of the specified pressure drop.

C-4.8.1 Install the test drier, adjacent lines, and pressure taps with the above limitations. Charge the system with an adequate amount of the specified refrigerant which meets the requirements specified in Annex J. Remove the non-condensable gases (air) from the system. Circulate the refrigerant through the loop. Adjust the flow control valve to give at least five different operating conditions between 50 percent and 150 percent of the specified pressure drop. Record the flow rate and pressure drop data for at least five different steady-state operating conditions.

C-4.9 Refrigerant to be Used

HFC 43-100 mee (2, 3-dihydro decafluoropentane) or Water (R718).

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C-5 TEST PROCEDURES

Install the test drier, adjacent lines, and pressure taps with the above limitations. Charge the system with an adequate amount of the specified refrigerant which meets the requirements specified in Annex J. Remove the non-condensable gases (air) from the system. Circulate the refrigerant through the loop. Adjust the flow control valve to give at least five different operating conditions between 50 percent and 150 percent of the specified pressure drop. Record the flow rate and pressure drop data for at least five different steady-state operating conditions.

C-6 HANDLING OF FLOW CAPACITY TEST DATA

C-6.1 Correct the observed flow rate data for instrument calibration, and convert to kilograms per second (pounds per minute) units.

C-6.2 Correct the observed pressure drop for the effect of the refrigerant column above the mercury, and convert to kilopascal (or pounds per square inch) units. Correct the flow rate for the difference in liquid refrigerant density between the measured temperature and 43 °C (110 °F) using the relationship that the mass rate of flow for constant pressure drop is proportional to the square root of the liquid refrigerant density.

C-6.3 Plot a point for each of the several operating conditions recorded for a particular test drier on a log-log graph of flow rate vs. pressure drop. Interpolate between these points to determine the flow capacity of this particular drier at the specified pressure drop.

C-6.4 Extension of Data

Experience has proved that it is permissible to extrapolate flow capacity data experimentally determined for one refrigerant to the other common refrigerants by means of simple calculations based on the relationship that the mass rate of flow for constant pressure drop is proportional to the square root of the liquid refrigerant density.

ANNEX D

(*Clauses* 5.2.1, 5.2.6, 5.2.11, *and* 5.3.3)

WATER CAPACITY

(*Normative*)

D-1 PURPOSE

The purpose of this annex is to prescribe test methods for determining flow capacity and water capacity performance characteristics of liquid line refrigerant driers.

D-2 GENERAL

This standard applies only to those driers that employ a desiccant.

D-3 STANDARD TEST METHOD FOR DETERMINING THE WATER CAPACITY OF DRIERS

D-3.1 Principles of Water Capacity Testing

The test method prescribed in this annex involves adding a known amount of water to the test drier, charging a known amount of refrigerant into the test drier, allowing the contained mixture to reach equilibrium, and then determining the equilibrium point dryness of the refrigerant charge using a Karl Fischer coulometric titrator.

D-3.2 To make a comprehensive evaluation of a drier, it is necessary to repeat the above procedure with various amounts of water added to each of several driers and at various fixed temperatures. This process permits the plotting of isotherm curves of EPD versus water capacity. This entire procedure must be repeated with each different refrigerant for which the drier is being calculated.

D-4 APPARATUS

The following apparatus is required and shall be prepared as noted:

D-4.1 A Constant-temperature Bath or Cabinet, that will maintain a given set temperature with an accuracy of ± 1 °C and is capable of being set at any temperature within the range of desiccant use. The equilibration vessel can be placed inside a constant-temperature cabinet.

D-4.2 An analytical balance**,** having a sensitivity of 0.000 1 g.

D-4.3 A pan-type balance, having a sensitivity of 0.01 g and a capacity of 5 000 g.

D-4.4 A stainless steel equilibrium vessel with minimum capacity of 300 cc and a stainless steel transfer vessel of

25 ± 5 cc capacity. These vessels must have maximum working pressure in excess of anticipated test pressure.

D-4.5 A Karl Fischer coulometric titrator, (note that the automatic concentration calculation feature of this equipment may be used) Also, a flow meter may be used per titrator instructions, a heat source and temperature monitoring device, a vacuum pump with a micron gauge and a 3 A°/4 A° molecular sieve dryer.

D-4.6 Stainless steel and/or Polytetrafluoroethylene (PTFE) tubing, adapter fittings, and needle and isolation valves as required to complete the assembly shown in Fig. 4.

D-4.7 Assembled test apparatus shall be adequately dried and leak tested.

D-5 PREPARATION OF TEST DRIER

D-5.1 Install the test drier in moisture charger such as is shown in Fig. 3. The drier should be installed in a vertical position and with the flow backward, that is so the air will flow into the drier through the normal outlet connection. Introduce the desired amount of water into the test drier.

D-5.2 Install the entire air circulation loop in a cabinet held at a temperature of 77 ± 3 °C (170 ± 5 °F) and operate the circulator for at least 24 h. (The purpose of this is to achieve uniform distribution of water throughout the desiccant).

D-5.3 The test drier shall be weighed before installation on the moisture charger and after removal from the air circulation loop. The difference in mass is the water added. Accuracy of weighing shall be such that error is a maximum of 3 percent of the mass of the water added.

Precautions: Since any loss of volatiles such as from the exterior finish would introduce an error in the determination of the amount of water added, it is generally advisable to prebake the drier for several hours at 77 °C (170 °F).

D-6 TEST PROCEDURE

D-6.1 Pure refrigerant shall be used for the test.

D-6.2 The refrigerant shall be charged into the test drier, but it shall not exceed 80 percent liquid full at the maximum anticipated temperature.

NOTE — The test drier should be evacuated by exposing to a vacuum for 5-10 s prior to refrigerant addition.

D-7 DETERMINATION OF EQUILIBRIUM POINT DRYNESS (EPD)

D-7.1 Prebake test drier for 3 h at 77 °C (170 °F).

NOTE — The prebake is intended to reduce error in this test from the loss of volatiles, such as from the exterior finish.

D-7.2 Charge the test drier with water as per **D-5**.

D-7.3 Charge the test drier with the desired refrigerant.

D-7.3.1 Pull a vacuum for one minute.

D-7.3.2 Chill the vessel sufficiently to allow refrigerant transfer. Connect the refrigerant liquid supply to the test drier using a commercially available non-venting hose that has been thoroughly dried. Place the connected vessel on a suitable balance and weigh it.
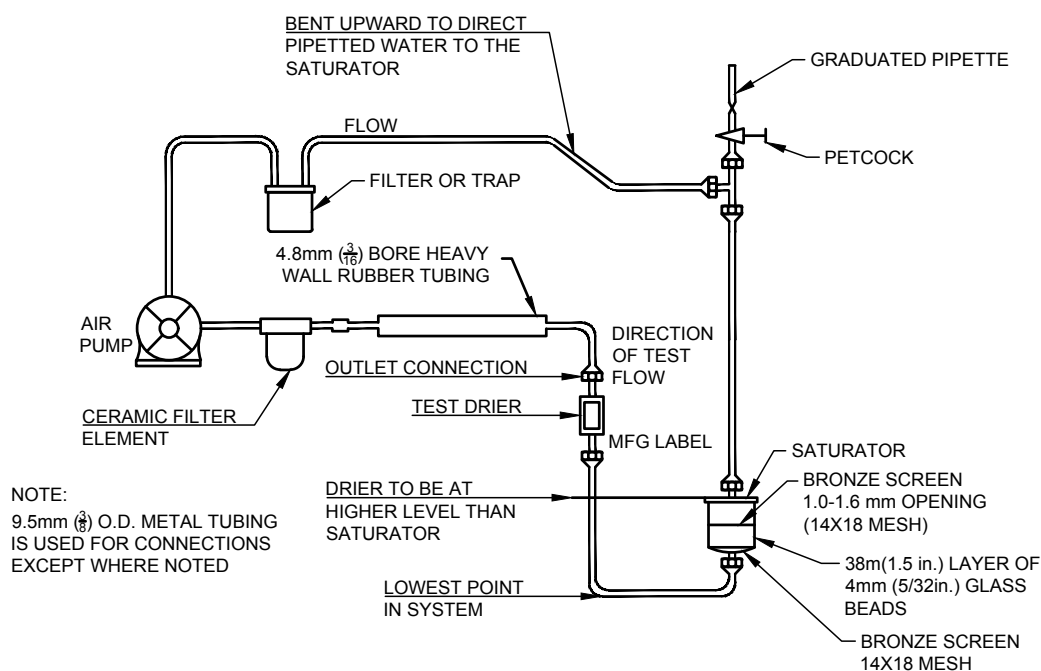

Fig. 3 Containment Addition Test Setup

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D-7.3.3 Open the valve and add liquid refrigerant to the test drier. Do not charge the test drier with more than 80 percent liquid capacity as this may cause a hydrostatic condition in the vessel possibly resulting in rupture and personnel injury.

D-7.3.4 Close the refrigerant supply valve and disconnect the flexible line from the test drier. Cap the test drier to prevent leakage and weigh it.

D-7.3.5 Install the test drier in the test apparatus as shown in Fig. 4.

D-7.3.6 The test drier shall be allowed to reach equilibrium. Place the test drier in constant temperature cabinet at the desired temperature for at least 48 h. Weigh the test drier periodically to check for leaks and agitate it lightly by tipping it back and forth a few times.

D-7.3.7 Measure the water content according to the method specified in Annex J or IS/ISO 17584.

D-7.3.8 Water content of equilibrated refrigerant/ test drier shall be measured in triplicate. If the results vary by more than 2 mg/kg (2 ppm) and by more than 10 percent of the mean, the test shall be repeated.

D-8 PROOF OF EQUILIBRIUM

Proof that equilibrium exists or that a chemical reaction maybe occurring in a system comprising the drier, the refrigerant, and water shall be obtained by the following procedure:

At the conclusion of the **5.2** procedure, the test drier with a relatively high-water content is kept for a period of two weeks at 52 °C (125 °F). The **5.2** procedure is then repeated. If the EPD falls within 2 ppm or 10 percent of that obtained originally, equilibrium has been proven. If such results are not obtained, repeat the procedure. A persistent and appreciable increase in EPD may indicate a chemical reaction and may serve as the basis for rejection of the drier.

D-9 STATISTICAL METHOD FOR DETERMINATION OF WATER CAPACITY

D-9.1 This presents a statistical method applied to the results from testing sets of samples of production driers to establish a rating which will be equal or exceeded by 90 percent of those produced.
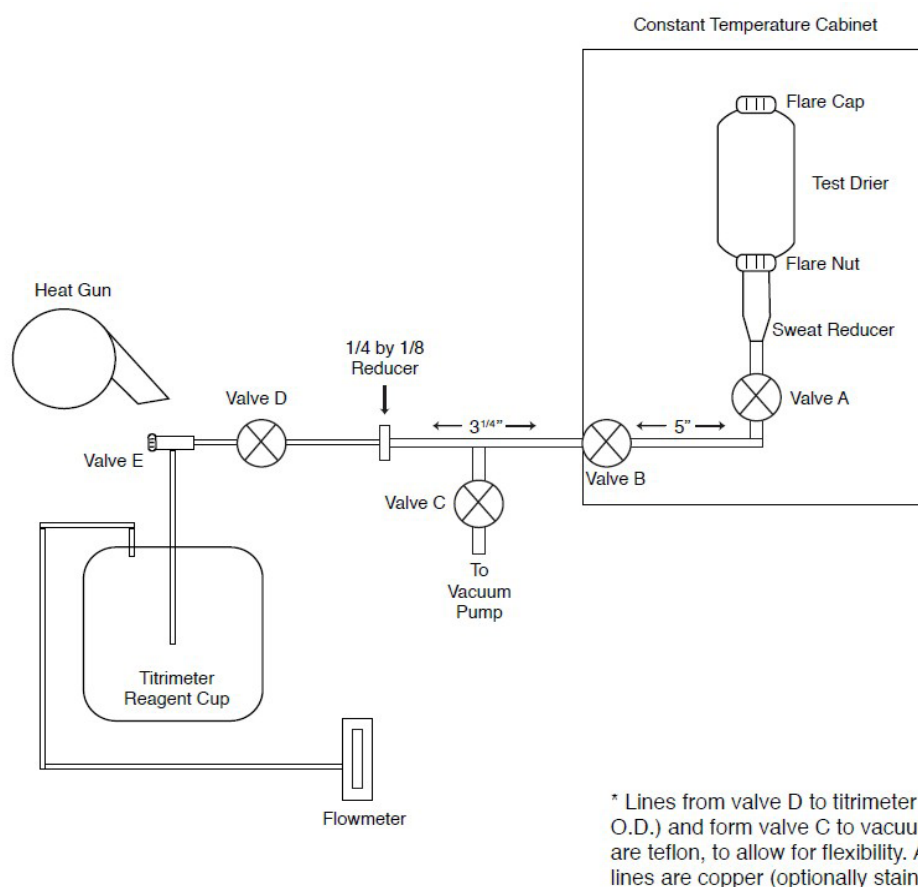

FIG. 4 WATER CAPACITY TEST LOOP

D-9.2 Introduction

D-9.2.1 When several determinations of the equilibrium point dryness (EPD) of a single drier are made by the procedure given in **D-7**, a series of values will be obtained because of variations in analytical procedure. The average of these results is more reliable than any single result. This average also becomes more reliable as more values are used in the calculation of the average.

D-9.2.2 When the average EPD of second drier is calculated from several determinations, this value will differ from the average of the first drier because of the manufacturing variations. The overall average of the two driers is more representative of the production line driers than is the average of a single drier. The overall average of several driers is still more representative.

D-9.2.3 In order to compensate for these testing and manufacturing variations, a statistical procedure is available for arriving at a rating that will guarantee any percent compliance desired.

D-9.2.4 This rating procedure is statistical analysis of results obtained from tests on a group of six driers, and the rating obtained by this procedure will be such that the average water capacity of duplicate tests on any set of six driers will equal or exceed the rating in 90 percent of all cases.

D-9.2.5 The proforma for report of observed ratings for water capacity and refrigerant flow capacity at standard rating conditions is given at Table 5.

D-9.3 Rating Procedure

D-9.3.1 *Preliminary*

The approximate water capacity of a drier shall first be determined by the test procedure outlined in **5.2**. Two driers for each standard condition are usually sufficient for this determination.

D-9.3.2 *Procedure*

Three driers are then pre-loaded at this pre-determined capacity. Duplicate EPD determinations are made for each drier. The average EPD for each drier and the overall average for the six determinations is then calculated. Another set of three driers is then evaluated at an adjusted capacity so that the overall average EPD's of the two sets will bracket the standard EPD.

D-9.3.3 In this procedure, duplicate EPD determinations per drier are required. This procedure slightly reduces the variations inherent in the method. Most important, it provides a check on the precision of the method. The maximum range for duplicate EPD determinations shall not exceed the following (*see* Table 6):

Table 6 Maximum Range for Duplicate EPD Determinations

(*Clause* D-9.3.3)

Sl No.	Refrigerants	Maximum Range for Duplicate EPD Determinations
(1)	(2)	(3)
i)	R 22	6 ppm
ii)	R 134a	6 ppm
iii)	R 245fa	5 ppm
iv)	R 404A	6 ppm
v)	R 407C	6 ppm
vi)	R 410A	6 ppm
vii)	R 502	6 ppm
viii)	R 507A	6 ppm

D-9.3.4 If the above range is exceeded, the test data shall be discarded, and the test shall be repeated after the analytical procedure has been reviewed.

D-9.3.5 The two EPD set averages are plotted on graph paper, plotting capacity on the vertical axis and EPD

Table 5 The Proforma for Report of Observed Ratings

(*Clause* D-9.2.5)

PROFORMA FOR REPORT OF RATINGS					
Refrigerant		*Standard Rating Conditions*		*Ratings*	
	Group No.	Standard Temp.	Water in Refrigerant (EPD)	Water Capacity	Refrigerant Flow Capacity at 6.9 kPa Pressure Drop
		°C	ppm	drops	kW
Refrigerant, R 22 (chlorodi fluoromethane CHCIF,)	I	24	60		
	II	52	60		
Refrigerant, R 502 (chlorodifluoromethane/monochloropentafluoro ethane, R 22/R 115)	III	24	30		
	IV	52	30		

on the horizontal axis. A straight line is drawn between these two points. A vertical line is drawn from the standard EPD to the straight Line. A horizontal line is then drawn from the point of intersection to the vertical axis. This point of intersection with the vertical axis gives the 'set average' at the standard EPD.

D-9.3.6 The six individual 'duplicate averages' are now plotted on the same graph. The vertical distance of each point from the straight line is determined in the units of capacity. The maximum value above the line is added to the maximum value below the line. The sum of these values is called the 'range'.

D-9.3.7 *Typical example*

Data Collected:

90 Drops of Water Added			110 Drops of Water Added		
Drier No	EPD	Average	Drier No	EPD	Average
1	10.5	11.2	4	18.5	19.3
	12.0			20.0	
2	13.0	13.8	5	15.6	15.5
	14.5			16.0	
3	13.0	13.5		13.0	14.0
	14.0			15.0	
Average	12.8		Average	16.2	

a) Determination of Range.

Range = 13 + 18 = 31 Drops

b) Determination of set average.

Enter the chart at EPD of 15 ppm, and read vertically to intersection with capacity line. Proceed horizontally and read capacity of 103 drops.

c) Sample calculations.

Water capacity rating (based on set of 6 driers) = $103 - 0.36 (31) = 91$ drops

D-9.3.8 By using the 'set average', the 'range', and a multiplication factor of 0.36 taken from the statistical tables, the water capacity rating is calculated as follows:

$$\text{Water rating} = A - 0.36 \times r$$

where

A = set average and

r = range

D-9.3.9 When driers are pre-loaded at the rated water capacity, it can be guaranteed that at least 90 percent of averages of sets of six driers, with duplicate tests for each drier, will equal or exceed the rating.

ANNEX E

(*Clause* 5.4.1 *and* 5.4.3)

OVERALL FILTER EFFICIENCY AND CONTAINMENT CAPACITY TEST

(*Normative*)

E-1 PURPOSE

Purpose of this annex is to prescribe laboratory test method for evaluating the containment (filtration) capacity of filters and filter driers used in liquid lines of refrigeration systems.

E-2 GENERAL

E-2.1 This test method evaluates the capability of liquid-line filters and filter driers only for removing and retaining solid particles of a standard test contaminant.

E-2.2 The test method may be applied to all hermetic refrigerant liquid-line filters and filter driers up to and including line size 23 mm.

E-2.3 The technique employed in this standard is the one-pass test method. In this test, a clean-up filter is installed down-stream of the test sample and is designed to retain and prevent recirculation of most of the contaminant particles that are not collected by the test sample in the first pass.

E-2.4 Filter driers have the added capability of removing and retaining certain dissolved contaminants. This annex does not provide measurement of this capability.

E-3 MATERIAL AND APPARATUS

E-3.1 Test Containment

E-3.1.1 *General*

The test contaminant will be a blend of 50 percent coarse test dust as received and 50 percent retained in a 200 mesh screen. For dust standard refer ISO 12103-1.

E-3.1.2 *Preparation of Test Contaminant*

To prepare the blend of contaminant, first wet-screen a quantity of coarse test dust on Tyler 200 mesh screen (particle retention = 74 mm). This is done by placing

a portion of the coarse test dust on a 200 mesh screen and running water through the screen while stirring the course test dust with the fingers. Discard the fine particles passing through the screen. The + 200 mesh particles collected on the screen are removed and dried for one hour at 110 °C. The test contaminant is prepared by mixing 50 percent by mass of the coarse test dust as received after drying for one hour at 110 °C with 50 percent by mass of the + 200 mesh screen dusted.

E-3.1.2.1 *Particle size analysis*

The coarsest dust as received and the blend used as the test contaminant have the approximate particle sizes listed in Table 7.

Table 7 Particle Sizes

(*Clause* E-3.1.2.1)

Sl No.		0-5	5-10	10-20	20-40	40-80	80-200
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	As received	12	12	14	23	30	9
ii)	Blend	6	6	7	11	32	38

E-3.2 Test Fluid — The test fluid shall be HFC 43-10 mee (2, 3 dihydro decafluoropentane) or any refrigerant which is in liquid form at room/test temprature and pressure. Care shall be taken to minimize evaporation or loss of test fluid.

E-3.3 Clean-Up Filter — The clean-up filter shall be a filter membrane of 0.8 mm pore size, which is used to estimate the amount of contaminant that passed through the filter under test.

E-3.4 Test Loop Specification

E-3.4.1 *Pump*

The pump shall be capable of producing a steady-state, non-pulsating flow sufficient to maintain the standard flow rate through the filter being tested at pressure drops up to 69 kPa.

E-3.4.2 *Reservoir*

The reservoir shall be of adequate size to maintain a suitable liquid level at the pump while the test apparatus is operating. To avoid potential problems with contaminant settling out in the reservoir, it shall be provided with a conical bottom outlet. The volume shall be such that the flow rate of the test fluid returning to the reservoir will create enough turbulence to prevent settling of the test contaminant. The entrance to the reservoir may be from any direction provided there is sufficient turbulence or imparted velocity to prevent the test contaminant from settling out of the test fluid.

E-3.4.3 *Bypass Valve*

A bypass valve shall be provided in the test apparatus in order to vary and control the flow rate through the filter under test. In some systems it may be possible to control the flow rare by regulating the pump speed.

E-3.4.4 *Flowmeter*

The flow meter may be of any generally accepted type, such as an orifice meter, venturi meter, or rotameter. The meter should be of such construction and installed in such a way that it does not create undue turbulence or disturb the steady-state flow in the test apparatus. The meter shall be calibrated to ensure that any error in indicated flow is less than 5 percent.

E-3.4.5 *Heat Exchanger*

A heat exchanger shall be provided (if necessary) to maintain the test fluid at 30 °C ± 6 °C.

E-3.4.6 *Manometer*

A manometer or other pressure-measuring device with a maximum error of 0.3 kPa shall be used to measure the pressure drop across the filter under test. If a U-tube manometer is used, the reading shall be corrected for the effect of the test fluid column on top of the measuring fluid. The pressure taps shall be located approximately 2 tube diameters upstream of the filter and 10 tube diameters downstream of the filter. Burr-free holes measuring 1.6 mm in diameter shall be used for pressure taps; however, in line sizes 6 mm or smaller, 0.8 mm diameter holes shall be used.

E-3.4.7 *Sight Glasses*

Sight glasses shall be installed in the test apparatus, so a visual check can be made to ensure that a solid liquid flow (no bubbles) exists at the inlet and outlet of the filter under test.

E-3.4.8 *Contaminant-Loading Device*

A contaminant-loading device shall be installed with bypass valves upstream of the filter under test to permit the introduction of the test contaminant into the test apparatus while it is in operation.

E-3.4.9 *Vent Valve*

A vent valve (optional solenoid valve) shall be located at the top of the test loop immediately ahead of the filter under test to permit the test fluid to drain freely from the filter under test and the clean-up filter. Test fluid discharged from the vent valve must be recovered.

E-3.5 Equipment Layout

The general layout of the test apparatus is shown in Fig 5. The line size used throughout the test apparatus may be any convenient size to cover a range of how rates that will permit the testing of filters of various size and prevent settling or trapping of the contaminant. The line adjacent to the filter under test shall have the same size as the fittings of the filter under test for a minimum straight distance of at least 15 tube diameters upstream and downstream of the filter under test.
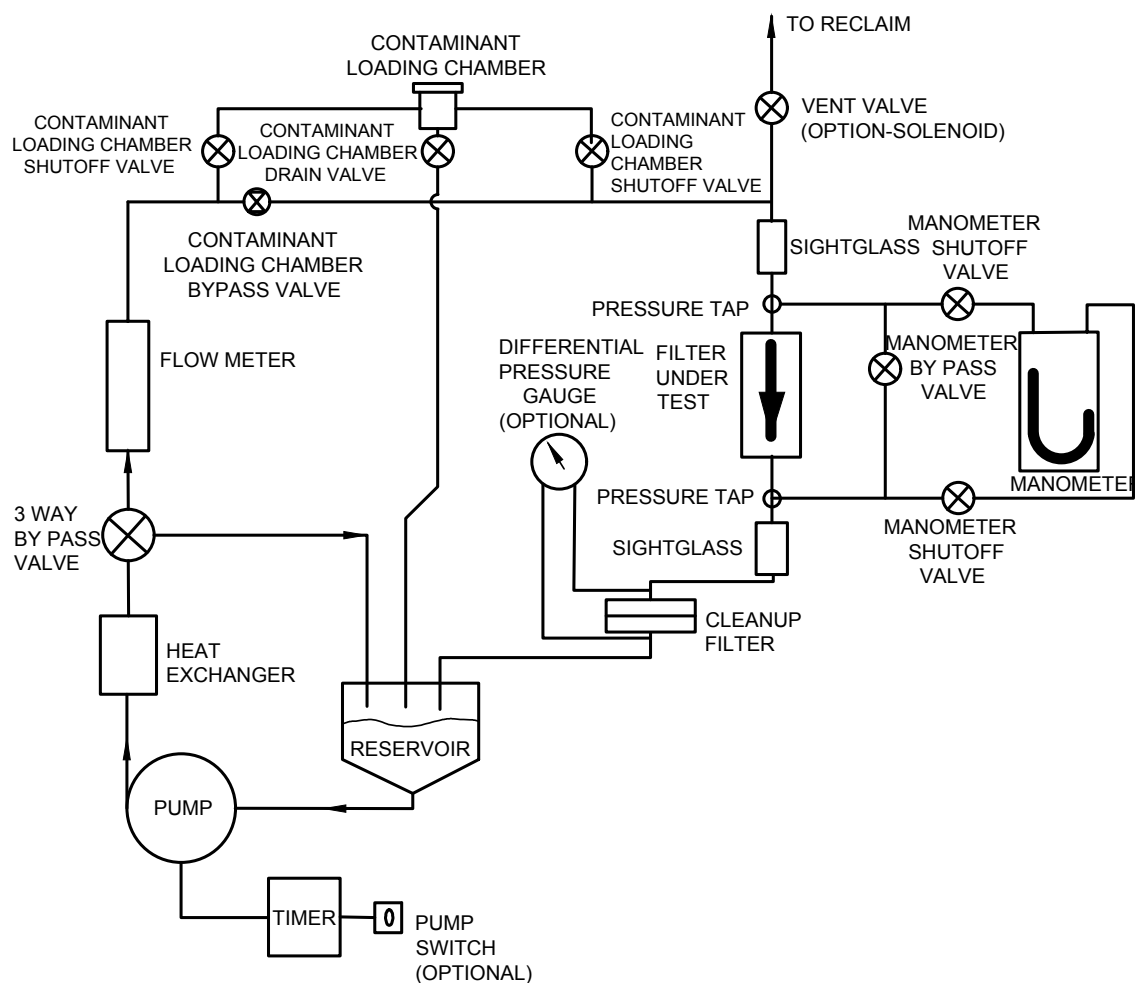
FIG. 5 FLOW TEST LOOP

E-4 TEST TO DETERMINE ACCURACY OF THE TEST SYSTEM

E-4.1 General

The test for accuracy consists of adding a specified amount of contaminant to the test apparatus with no filter under test and determining the amount of contaminant retained on the clean-up filter.

E-4.2 Procedure for Test Apparatus Accuracy

E-4.2.1 With only a fresh, pre-weighed clean up filter element installed, and the test apparatus filled with clean test fluid, start the pump and close the bypass valve slowly until the flow rate through the test loop equals the predetermined test flow rate agreed upon between the supplier and the customer. It is important that the test apparatus be clean before starting the test.

E-4.2.2 It is not necessary to add the same amount of contaminant as that added during the filter test since only a part of that contaminant was recirculated during the filter test. A total of 1g of contaminant added in at least three equal increments during three four-minute

operating cycles, as specified in **E-5.4.3**, is generally adequate. Allow the test apparatus to run one additional operating cycle after the last addition of contaminant.

E-4.3 Required Accuracy — The test apparatus shall be considered accurate if the clean-up filter retains at least 95 percent of the contaminant added.

E-5 PROCEDURE

E-5.1 Operating Cycle — Most refrigeration systems operate on an on-off basis according to the demand for cooling. Therefore, the proper method for testing the filtration ability of a filter is to operate it in a test apparatus with interrupted flow such as would occur in an actual refrigeration system.

After the pump is starred and the flow rate adjusted, the contaminant is added at the beginning of the three-minute flowing cycle. This length of time is sufficient to carry the contaminant to the filter under test. At the end of the three-minute period, record the pressure drop, stop the pump, and immediately open the vent valve. This permits air to enter the test apparatus

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and the lines to drain for one minute. At the end of this time, close the vent valve and restart the pump. The velocity head from the liquid starting up impinges on the filter under test in the same manner as would occur in an actual system. Repeat the cycle described in **E-5.4.4**

E-5.2 Filter under Test Position — The Filter under test shall be vertical with the flow downward.

E-5.3 Test Parameters —The filter under test, line size, test flow rate, and end-point pressure drop shall be agreed upon by the supplier and the customer requesting the test.

E-5.4 Test Procedure

E-5.4.1 Install the filter under test and a new pre-weighed element in the clean-up filter. Open the bypass valve. Fill the test apparatus with a sufficient amount of clean test fluid so that, with the pump running, the reservoir is approximately half full. This will permit the returning test fluid to create turbulence in the reservoir.

E-5.4.2 With the pump running, close the bypass valve (or regulate the pump speed) slowly until the test flow rate is obtained. Allow the test apparatus to run for one or two minutes until a steady flow rate is maintained. Record the pressure drop across the filter under test produced by the test flow rate that is to be maintained throughout the test.

E-5.4.3 With the test apparatus operating, arrange the valves to bypass the contaminant-loading chamber, remove the chamber cap, and add a measured amount of test contaminant. Replace the cap and regulate the valves to slowly introduce the contaminant. Allow the test apparatus to operate, maintaining the test how rate. Record the pressure drop at the end of a three-minute running cycle. Shut off the pump and open the vent valve to allow the test fluid to drain from the filter under test for one minute.

E-5.4.4 Close the vent valve and restart the pump, adjust to the test flow rate if necessary, and repeat the cycle in **E-5.4.3** until the pressure drop after start-up reaches an equilibrium condition greater than the end-point pressure drop specified for the filter under test. As the pressure drop approaches the limiting value, it may fluctuate above or below the endpoint pressure drop during the running cycle due to rearrangement of contaminant on the filter. When the pressure drop remains above the end-point pressure drop, no further contaminant shall be added to the test apparatus.

E-5.4.5 Adjust the increment of contaminant addition so that the end-point pressure drop is reached within 6 to 12 additions. Slightly different results might be obtained if an excessive number of cycles are used. Renew the clean-up filter if the test flow rate cannot

be maintained. Retain all clean-up filters for use in the contaminant-loading calculation.

E-5.4.6 After the end-point pressure drop is reached or exceeded, repeat five 4 min cycles at the test flow rate with no contaminant addition.

E-5.5 Mass of Contaminant

Remove the filter element from the clean-up filter and thoroughly dry it in a 110 °C oven before reweighing to determine the mass of contaminant that passed through the filter under test.

E-6 CALCULATION OF RESULTS

E-6.1 Determine the Filter Efficiency (E_f):

Data Required:

M_t = total mass of containment added to test apparatus during test (containment loading).

M_{cf} = mass of containment on clean-up filter.

Calculation

$$E_f = (M_t - M_{cf}/M_t) \times 100 \%$$

E-7 Plot a graph of contaminant loading (M_t) as the abscissa versus pressure drop (ΔP) as the ordinate (an exponential fit trendline will fit most data generated; if this fit is not possible, hand-fit a trendline to the data points). From the graph, read the contaminant loading at the end-point pressure drop.

E-7.1 Compute the contaminant capacity (M_c) by applying the filter efficiency (E_f) to the contaminant loading (M_t) determined from tire graph:

$$M_c = M_t \times E_f/100 \text{ g}$$

E-8 SAMPLE CALCULATION

E-8.1 Test flow rate of 4.5 kg/min (0.075 kg/s) for refrigerant. End-point pressure drop of 30 kPa. Contaminant added in ten 1.2 g increments for a total of 12 g to produce a final pressure drop in excess of the end-point pressure drop.

The contaminant remaining in the test apparatus after the filter under test was removed was found to be.

E-8.2 M_{cf} = mass of contaminant on cleanup filter

$$M_{cf} = 3.23 \text{ g}$$

Filter efficiency: $(12 - 3.23/12) \times 100 \% = 73 \%$

As shown in Fig. 6, plot a graph of contaminant loading versus filter under test pressure drop. From the graph, read the contaminant loading at 30 kPa. Compute the contaminant capacity by applying the filter efficiency to the containment loading value read from the curve.

Containment capacity = $11.2 \times 0.73 = 8.2$ grams

At 4.5 kg/min, refrigerant, Filter Efficiency = 73%, Containment capacity at 30 kPa = 8.2 g.
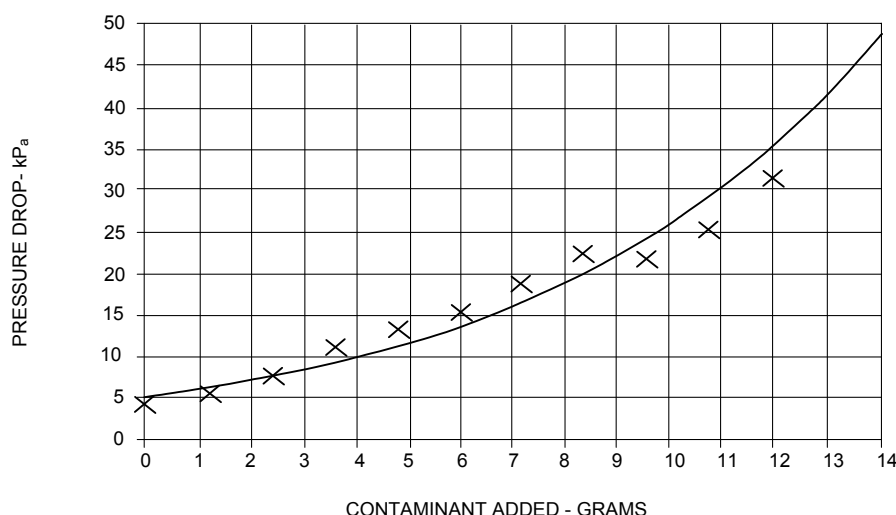
Fig. 6 Pressure Drop Versus Contaminent Added

ANNEX F

(*Clause* 5.5.3)

ACID CAPACITY TEST

(*Informative*)

F-1 CONSIDERATION

F-1.1 This annex presents a method for measuring the ability of filter-driers to remove a specific organic acid from a solution of refrigerant HFC 43-10 mee (2, 3 dihydrodecafluoropentane) and oil.

F-1.2 Oleic acid was considered because it is a commercially pure and readily available organic acid with a molecular weight similar to some acids found in some samples of oil from refrigeration system burnouts.

F-1.3 Refrigerant HFC 43-10 mee (2, 3 dihydro decafluoropentane) was considered because it is a commercially available pure refrigerant which is easily handled and reclaimed because of its high boiling point.

F-1.4 It is recognized that this procedure does not truly represent the situation that can exist in the liquid line of a refrigeration system and, therefore, it does not necessarily predict the exact acid capacity of a drier in a refrigeration system.

F-1.5 However, the test does serve as a useful method for comparing the ability of driers to remove organic acids from refrigerant oil system.

F-2 PURPOSE

F-2.1 This annex provides a laboratory test method that is suitable for determining the ability of various refrigerant filter-driers and adsorbents to remove a specific organic acid.

F-2.2 This annex provides a laboratory test method for measuring the weight of oleic acid removed from a refrigerant-oil mixture by a refrigerant filter-drier containing an adsorbent desiccant material which can remove acid by adsorption and/or chemical reaction.

F-3 APPARATUS AND REAGENTS

**F-3.1** The reservoir consists of a metal shell with a volume approximately 3 liters.

Guideline — A two-core replaceable type filter-drier shell has been found in a convenient container.

F-3.2 The pump should be a small, seam less, magnetically driven centrifugal pump made from a material suitable for use with refrigerant. Consider seal-less centrifugal magnetic drive pump ideal for applications such as chemical recirculation and chemical transfer.

F-3.3 A flow meter of conventional design can be used, is suitable for measuring a flow rate in the range of 800 to 1 000 ml/min. A rotameter is recommended.

F-3.4 A temperature controller and thermometer shall be installed on the system. This device shall be suitable for controlling the heating tape on the reservoir (Fig. 7), to maintain the circulating refrigerant mixture at a temperature of 37.8 ± 1 °C (100 F ± 2F).

F-3.5 The valves and connecting tubing for the circulating system, can be made from commonly available brass, copper, or stainless-steel materials, using ¼" (6.35 mm) line size.
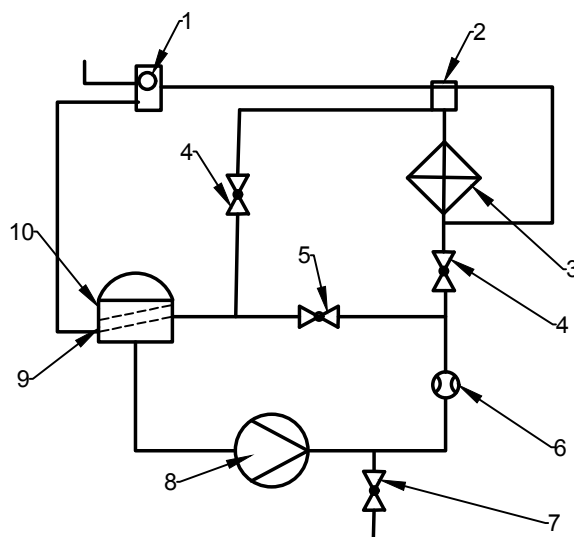
1. Temperature indicator
2. Temperature sensor
3. Filter to be tested
4. Spherical/Ball valve
5. Bypass ball valve
6. Rotor flow meter
7. Drain valve
8. Pump
9. Heater
10. Reservoir/Liquid accumulator

Fig. 7 Acid Capacity Test Loop

F-3.6 The distillation apparatus can be made of conventional laboratory glass-ware. The recommended equipment includes a suction flask of 1 liter capacity and a water-cooled condenser. The flask should be heated with a water bath.

F-3.7 The oil used shall be refrigeration grade naphthenic oil with a viscosity of approximately 32 centistokes (150 SUS at 100 F).

F-3.8 The oleic acid used shall be clear liquid grade.

F-4 METHOD OF TEST

F-4.1 The adsorbent material used in the refrigerant filter-driers generally consists of desiccant which also removes moisture from the refrigerant. The adsorbent must be activated properly to attain maximum acid removal ability. For the common desiccants the following reactivation condition shall be used. Activated alumina , molecular sieves form 3A°/4A° in loose beads as well as bonded core form shall be re-activated at 240 °C (392 °F), silica gel at 232 °C (450 °F) for five hours. The activation oven should be ventilated, but no special purge gas is required. If purge gas is used it must be dry and nitrogen gas is preferred. After activation the material shall be cooled in a closed container before being loaded into the test drier shell.

F-4.2 When granular or bead type adsorbent is being evaluated, it be contained in a metal shell. The adsorbent shall be retained by filter glass pads supported by a screen or perforated metal plate at the inlet and outlet ends of the adsorbent bed. When an adsorbent is being tested, the 'loss on ignition' of the adsorbent can be determined and reported with the acid capacity results. This 'loss on ignition' is the percent weight loss obtained when a sample of the reactivated adsorbent is heated in 1 h at 1 000 °C (1 832 °F).

F-4.3 If a commercial filter-drier is being tested, it shall be used as received. While it is possible to run tests with various size filter-driers, the preferred size is one

with a nominal 8 cubic inches of desiccant. Weigh the drier to be tested to the nearest 0.1 g before installing it on the apparatus.

F-4.4 Assemble the equipment illustrated in Fig. 7. Flow thru the filter drier being tested shall be vertically upward to eliminate the possibility of an air pocket in the adsorbent bed. Add 2 liters of refrigerant to the reservoir and circulate this refrigerant throughout the system. This will clean the system and remove any residual contaminants.

F-4.5 Calibrate the flowmeter while the refrigerant is being circulated at 37.8 °C (100 °F). This is done by collecting a portion of the refrigerant as it flows into the reservoir, while noting the reading on the flowmeter. Calibrate the flowmeter at four or more different flow rates in the range of 750 to 1 000 ml/min. Plot these values on a graph to obtain a permanent calibration curve. The refrigerant remaining after the cleaning and calibration should be distilled and re-used.

F-4.6 The refrigerant and oil used shall be dry. The test results are based on a 'dry system'. It is important that the system be dry since it is known that the acid removal ability varies with the moisture content of the desiccant.

F-4.7 With the filter-drier installed on the system shown in Fig. 7, add 1 800 ml of refrigerant HFC 43-10 mee (2, 3 dihydrodecafluoropentane) to the reservoir through the top filling port. Weigh 54.00 g of oil in a 250 ml beaker. Add the desired weight of oleic acid to this beaker, mix with the oil, and add the mixture to the reservoir. Rinse the beaker, stirring rod, and funnel with 200 ml of additional refrigerant, and add this to the reservoir. The resulting mixture contains 3 percent oil by volume. Weighing of the oil and oleic acid shall be done to the nearest .001 grams. While adding the refrigerant liquid through the filling port, the reservoir maybe vented at the filter-drier connection.

F-4.8 Circulate the refrigerant oil-acid mixture through the bypass line for five minutes with valve B and C closed. Then open these valves and close valve A in the bypass line, so as to circulate the mixture through the drier being tested. Adjust the liquid circulation rate to obtain a flow rate of 850 ± 100 ml/min. To attain proper equilibrium, circulate the liquid through the drier for a period of 7 days ($\pm$ 1 hour). The liquid temperature during the circulation shall be maintained at 37.8 ± 1 °C (100 ± 2 °F).

F-4.9 At the conclusion of the circulation period, drain the system to obtain all refrigerant-oil-acid mixture. Collect and weigh the refrigerant mixture. Weigh the filter-drier being tested and compare this weight to the original weight, to determine the amount of refrigerant mixture remaining in the filter-drier. The total weight of refrigerant oil-acid mixture at the end of the test shall be compared with that at the beginning of the test to determine if any leakage has occurred. The leakage shall not exceed 5 percent.

F-4.10 Set up a laboratory distillation apparatus. It is suggested that this include a one-liter suction flask, which is attached to a water-cooled glass condenser. The flask shall be heated by steam from a hot water bath. Use several boiling beads (preferably hollow glass beads 2 mm diameter) in the flask to avoid bumping. To avoid excessive boiling, only a small area (50 mm/two-inch diameter) of the flask containing refrigerant is exposed to the steam from the hot water bath. This apparatus will permit distilling and collecting the refrigerant from the mixture removed from the circulating equipment.

F-4.11 Periodically add portions of the refrigerant oil mixture to the flask and distill of the refrigerant. The boiling point of HFC 43-10 mee (2, 3 dihydrodecafluoropentane) is 55 °C. The refrigerant collected maybe reused. After all the refrigerant-oil solution is in the flask, watch the boiling action carefully. When the boiling subsides, remove the flask from the hot water bath immediately to avoid over heating the remaining oil. Such overheating might cause decomposition to form additional acid. Any remaining amount of refrigerant shall be removed by evacuating the flask. Break the vacuum several times and re-evaluate to remove all the remaining refrigerant vapor from the oil. Record the weight of the oil collected.

F-4.12 Determine the acid number of the oil, with the following exceptions: The oil sample size shall be approximately 25 grams. This will permit duplicate titrations. The amount of titration solvent shall be 125 ml. Use 5 drops of indicator and sweep the titration beaker with dry nitrogen as prescribed. Titrate with 0.1 N alcoholic potassium hydroxide. This can be prepared by purchasing standardized 0.10 N potassium hydroxide (alcoholic) and diluting with methyl alcohol. Repeat the titration with a second 25 gram sample and average the results.

Safety precaution: Avoid breathing the fumes carried out of the titration beaker by the nitrogen purge gas. Toluene can be toxic.

F-4.13 The titration shall be done by adding potassium hydroxide until a full green end point is reached, which persists for 15 s. Make a similar blank titration on 125 ml of titration solvent containing 25 grams of new refrigeration oil. In this way the blank titration will compensate for any slight acidity in the starting materials, and also compensate for the variations in judging the end point color of the titration.

F-5 CALCULATIONS

F-5.1 The grams of oleic acid remaining in the oil is calculated as follows:

The titration value less the blank titration gives the net titration (ml). Net titration × exact normality of the potassium hydroxide × 0.282 5 divided by the weight of oil titrated = grams of oleic acid in one gram of oil. When two titrations are made, then two such values are obtained, and they are averaged to yield the average weight of oleic acid remaining per gram of oil. This value is multiplied by 54.0, which is the weight of the oil at the start, to obtain the total weight of the acid remaining at the end of the test. The starting weight of the oil is preferred over the collected weight since any leakage, adsorption or other change in oil weight probably occurred after acid equilibrium was nearly complete.

F-5.2 The acid removed by the desiccant equals the acid added at the start minus the calculated weight of the acid remaining at the end of the test. This amount should be divided by the weight of the desiccant used × 100 to report the results on the basis of 'gram of oleic acid removed per 100 grams of desiccant'. This value should be plotted against the acid number of the oil.

F-5.3 Example Calculation

Material Added

2000 ml × 1.56 g/ml*	= 3 120 g
Oil	= 54.00 g
Oleic acid	= 4.08 g
Total	= 3 178 g
Material Recovered:	
Refrigerant-oil-acid liquid collected	= 3 055 g
Weight of filter-drier, Start	= 300 g
Weight of filter-drier, End	= 376 g
Weight gain	= 76 g
Total Material recovered	= 3 131 g
% Material Recovery	= (3 131 × 100)/3 178 = 98.5 %
Weight of Acid oil recovered	= 51.70 g
Titration result	: (ml of 0.1 N KOH)
Test-1	: 5.60 ml for 25.2 g oil
Test-2	: 5.66 ml for 26.4 g oil
Blank titration	: 0.65 ml
Oleic acid per g of oil:	
Test 1: (5.60 − 0.65) × 0.010 0 × 0.282 5/25.2	= 0.000 555 g
Test 2: (5.60 − 0.65) × 0.010 0 × 0.282 5/26.4	= 0.000 529 g

Average oleic acid per gram of oil	= 0.000 542 g
Acid remaining in the oil (collected and uncollected) at the end of the test: 54.0 × 0.000 542	= 0.029 4 g
Oleic acid removed	= 4.08 − 0.029 4 = 4.051 g
Organic acid capacity, grams/100 grams adsorbent	= 4.051 × 100/70 = 5.79 g/100 g
(Drier contained 70 g of adsorbent)	
Acid number of oil: (0.000 542 × 56 × 1 000)/282.5	= 0.11 mg. KOH/g of oil

Use actual density of refrigerant

F-6 TEST REPORT

F-6.1 The acid capacity test results can be reported either as the grams of acid removed by a specific commercial filter-drier, or as grams of acid removed per 100 grams of adsorbent. In either case, the test value corresponds to a given equilibrium acid number in the oil remaining. The test method maybe used to compare the acid capacity of several different filter-driers or different adsorbents, when compared at the same equilibrium acid number value. The method can also be used to obtain a complete equilibrium adsorption curve for a particular drier. Such a curve would involve a series of test points plotting acid capacity of the desiccant versus acid number in the remaining oil.

F-6.2 If the acid capacity of a given drier or adsorbent is desired at a specified level of acid number in the oil, then the test points shall be obtained above and below the specified acid number value. A line or curve drawn between these two points will permit graphical interpolation to obtain the acid capacity at the specified acid number value. Satisfactory accuracy will be obtained with the above procedure, if the test points above and below the final selected value are within 10 percent of the acid capacity of the final selected value.

F-6.3 The test procedure and measurements can be performed with a high precision. Variations in the test results are caused to a greater degree by variations in the adsorbents, than by the variation in the test procedure.

F-6.4 It is suggested to use HFC 43-10 mee (2, 3 dihydrodecafluoropentane) or any other refrigerant which is in liquid form at room/test temprature and pressure for this test.

ANNEX G

(*Clause* 5.6.4)

PRE-ADSORPTION TEST

(*Normative*)

G-1 GRAVIMETRIC METHOD – SUITABLE ONLY FOR LOOSE BEADS

G-1.1 Test Procedure

Place the porcelain crucible in the box-type resistance furnace and bake it at 550 °C for 1 h.

G-1.2 Take out the porcelain crucible from the furnace, place it in a vacuum drier, dry it under vacuum for 3 min, cool it to room temperature, and weigh its weight M_1 to an accuracy of 1 mg.

G-1.3 Quickly split apart the suction-line filter-drier, take out the granular molecular sieve, screen out the particles of a uniform granularity, take 8-12 g of sample, put it in the porcelain crucible and weigh its mass M_3 to an accuracy of 1 mg.

> NOTE — This process shall be completed within 2 min at a relative ambient humidity of less than 50 percent.

G-1.4 Place the porcelain crucible in the box-type resistance furnace and bake it at 550 °C for 1 h.

G-1.5 Take out the porcelain crucible from the furnace, place it in a vacuum drier, dry it under vacuum for 3 min, cool it to room temperature, and weigh its weight M_2 to an accuracy of 1 mg.

G-2 CALCULATION

Pre-adsorption is represented by the mass fraction 'X' of water in unit mass of product, which can be calculated:

$$X = (M_3 - M_2)/(M_3 - M_1) \times 100$$

where

$X =$ Water content of molecular sieve, percent

$M_1 =$ Mass of porcelain crucible, g

$M_2 =$ Combined mass of sample and porcelain crucible after baking, g

$M_3 =$ Combined mass of sample and porcelain crucible before baking, g

The calculation result shall have two decimal places. Take the arithmetic mean of two parallel tests as test result. The absolute difference between the results of any two parallel tests shall not be greater than 0.5 percent.

G-3 HEATING METHOD – SUITABLE FOR SOLID/BONDED CORE

G-3.1 Test Procedure — Collect solid/bonded core and carefully weight it to an accuracy of 1 mg.

G-3.2 Place it in an oven and heat it at 240 °C for 5 h.

G-3.3 Remove the core and measure the weight up to 1 mg.

G-3.4 Calculation

$$X = (M_1 - M_2)/(M_1) \times 100$$

where

$X_x =$ Water content of solid/ Bonded core, percent

$M_1 =$ Mass of core before heating, g

$M_2 =$ Mass of core after heating, g

The calculation result shall have two decimal places. The absolute difference between the results of any two parallel tests shall not be greater than 0.5 percent.

ANNEX H

(*Clause* 4.9)

ATTRIBUTION INDEX – FOR LOOSE BEADS

(*Normative*)

H-1 ATTRIBUTION INDEX

H-1.1 The attribution index of the desiccant in loose bead form, determined according to method indicated below, shall not be more than 0.25 percent.

H-1.2 Measure 136 ml of the beads and weigh to the nearest 0.1 g.

H-1.3 Take 210 ml bottle (100 mm high) and transfer the weighed sample.

H-1.4 Add 68 ml of trichloroethylene and seal the bottle. Place the bottle on a paint shaker, and allow shaking for 30 min. Remove bottle from the shaker and carefully.

H-1.5 Wash off and strain the fine dust particles through a 100 mesh screen with trichloroethylene.

H-1.6 Allow the fines to settle, decant the liquid and dry the fines at 120 °C.

H-1.7 Cool and weigh to the nearest 0.01 g.

H-1.8 For seives used with driers refer to **4.1** and **4.2** of IS 460 (Part 1) and **3.5.2** and **4.2** of IS 460 (Part 2).

ANNEX J

(*Clauses* C-4.8.1, C-5 *and* D-7.3.7)

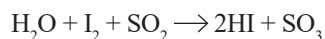## DETERMINATION OF WATER IN REFRIGERANT BY KF COLOMETRIC TITRATION

(*Informative*)

J-1 APPLICABILITY

J-1.1 The method specified here is for use with low, medium and high-pressure refrigerants.

J-2 CHEMICAL PROCESS

J-2.1 Karl Fischer(KF) titrimetry is based upon the redox reaction of water, iodine and sulfur dioxide:

$$H_2O + I_2 + SO_2 \longrightarrow 2HI + SO_3$$

The solvent is typically a mixture of methanol and a weak organic base (imidazole, pyridine, etc.) with the base serving to neutralize the reaction products. In coulometric KF titrimetry, iodine is generated at the anode in direct proportion to the amount of water introduced, and the end point is detected bi-amperametrically as the first appearance of excess free I_2. The added refrigerant eventually evaporates; hence, the solvent can be used repeatedly until either the SO_2 or the base solution is consumed.

J-3 LIMITATIONS

J-3.1 None of the refrigerants tested interfere with the titration. Oxidizing agents such as MnO_4, $Cr_2O_7^{-2}$, H_2O_2, Fe (III), Cu (II) and reducing agents such as S^{-2}, thiosulphates and Sn (II) will interfere. Also, certain compounds such as basic oxides and salts of weak acids ($NaHCO_3$, for example) can form water with the KF

reagent. None of these interferences are normally present in new or reclaimed refrigerants.

J-4 SENSITIVITY, PRECISION AND ACCURACY

J-4.1 Sensitivity

The sensitivity of the analyzer in this method using a 10 g sample is 1 ppm. Extreme care must be used in sample handling in order to achieve this sensitivity.

J-4.2 Precision and Accuracy

The mean of the analysis (X), standard deviation (σ) and 95 percent confidence limits (CL) established for the single operator precision of this method are shown in Table 8.

J-4.3 The data in Table 8 were calculated from replicate analyses of one sample (approximately 10 g) performed by one analyst over a period of two days.

J-4.4 The samples in Table 9 were tested for total percent recovery. They were prepared by analyzing R-22 to 7.1 ppm, and then contaminating the refrigerants with known amounts of water. The sample was then mixed for a period of 24 hours before analyzing. Results are shown in Table 9.

J-4.5 The total percent recovery for sample was 99.7 percent recovery for R-22.

Table 8 Single Operator Method Precision

(*Claus*e J-4.2)

Sl No.	Refrigerant	Mean	Standard Deviation	95 percent Confidence limit
		($\bar{x}$)	(σ)	
(1)	(2)	(3)	(4)	(5)
i)	Water PPM by Weight (R-22)	28.1	0.29	0.77

Table 9 Testing for Percentage Water Recovery

(*Clause* J-4.4)

Sl No.	Refrigerant	Original Value	Amount Contaminated	Calculated Total	Recovered Total	Percent Recovery
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Water PPM by *w*eight (R-22)	19.2	19	38.2	38.1	99.7

J-5 SPECIAL APPARATUS AND REAGENTS

a) KF coulometric titrator system (contains a drying tube for venting refrigerant, anode and cathode solutions, septum, and water vaporizer);

b) Drierite, 20-40 mesh;

c) Desiccator, containing Drierite;

d) Refrigerant sample cylinder, e.g. 50 ml, 500 ml, 1 000 ml stainless steel double ended 1/4 inch female pipe thread cylinders (1 800 psig), steel cylinder, 2.2 lb, single 9 gauge valve, 3/8 inch pipeneck, disposable can, 17 oz, or other suitable cylinder;

e) Stainless steel integral bonnet non-rotating stem valve, 1/4 inch male pipe thread X 1/4 inch female pipe thread;

f) Brass screwed-bonnet needle valve, 1/4 inch male pipe thread;

g) Male luer lock 10-32 standard thread needle connector, cut threads back 1/8 inch (threads are too long as received);

h) Needle, 19 gage luer lock, 4-1/2 inch length;

j) 1/4 inch compression fitting to 1/4 inch angle needle (AN) female flare adaptor;

k) Quick seal flare cap, No. NFT5-4, 1/4 inch tubular seal gasket;

m) Sample injection needle and valve attachment (*see* Fig.8). Remove the inner gasket-then drill and tap for a 10/32 inch standard thread through the center of the flare cap. Coat the threads with epoxy-then screw the needle connector (item No. 7) into the hole until snug, then allow the epoxy to set overnight. The needle is attached to the connector and the assembly then screwed onto the needle valve AN female flare adapter;

n) Syringe, 10 ml, gas tight; and

p) Syringe needle, 19 gage-4 inch (deflected point).

NOTE — For pipe threads IS 554/ISO 7-1 may be referred.

J-6 PROCEDURE

J-6.1 Verification

Verify that the instrument is operating accurately by injecting quantified moisture standard prior to sample testing.

J-6.2 Sample analysis -Refrigerant

NOTE — To minimize contamination from moisture, the sample should be introduced directly from the refrigerant sample cylinder into the coulometric titrator, i.e., avoid a secondary container transfer, whenever possible. Also, the effects of moisture contamination and phase distribution will be minimized if the sample container is 60 percent to 80 percent liquid filled with refrigerant. If the sample is a very high-pressure refrigerant, cool the cylinder to approximately 14 K below critical temperature (TC) of the refrigerant and allow 30 minutes for equilibrium to be established before starting the analysis.

J-6.3 Refer to the instruction manual for moisture analyzer installation and operation Instrument sensitivity should be set at 0.10 and a new septum should be attached.

J-6.4 Turn-on the analyzer and magnetic stirrer and wait until the background current ($\mu g\ H_2O$ per second) has reached a low, steady level. It may be necessary to 'shake' the titration vessel to contact (wash down) any water mist on the upper inside walls with the anode solution. Optimum levels are below 0.10 microgram of water per second (normally 0.02 to 0.05).
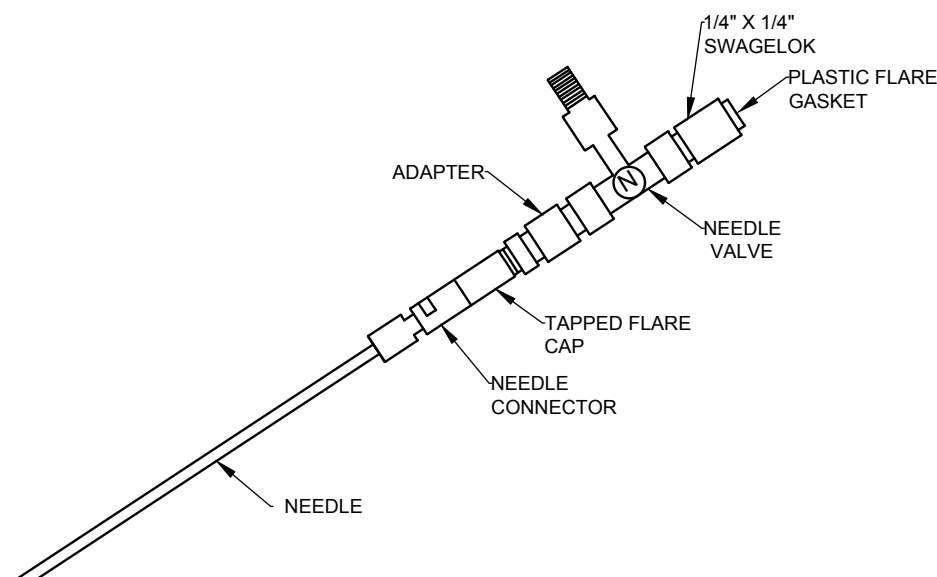

FIG. 8 NEEDLE ATTACHMENT ASSEMBLY USED FOR CYLINDER SAMPLING

NOTE — If after 15 min a low (< 0.1 μg per second) background current is not obtained or if the cathode solution turns a dark reddish brown color, turn off the moisture meter and, using a small funnel, renew both anode and cathode solutions. Also, should a negative background reading persist (free I2 in the anode solution), introduce a drop of methanol-water wetting solution into the vessel to eliminate the free I2 via reaction with water and produce a positive background. This wetting solution can be made by adding a small amount of water (typically less than 500 ppm) to methanol.

J-6.5 Using a heat gun, dry-off the valve threaded end of the sample cylinder valve that contains a pressure relief valve (2.4 to 2.76 Mpa or 350 psi to 400 psi) and cylinder stem valve (1/4 inch male pipe thread X 1/4 inch female pipe thread).

J-6.6 Remove the needle/needle valve attachment (*see* Fig. 8) from the oven or desiccator and immediately attach to the sample cylinder valve.

J-6.7 Open the refrigerant sample cylinder valve, then slowly open the needle valve and purge a small amount of sample liquid phase to flush the air from the needle (1 s to 2 s purge). Close both valves.

J-6.8 Using a heat gun (high position), carefully dry the needle for 20 s to 30 s.

J-6.9 Weigh the refrigerant sample cylinder plus attachment on a top loader balance (nearest 0.1 g) and record on a work sheet.

J-6.10 Using a clamp (or clamps) and weighted ring stand, invert and position the sample cylinder such that the needle punctures the septum and is immersed to the hub of the needle. The needle should be submerged about one inch below the KF solution surface.

NOTE — The background current will rise after inserting the needle, then return back to the normal low valve.

J-6.11 At this juncture it is assumed that the instrument has been turned on, preset for a 5 min titration start delay, verified, and that the background current is at a low (0.02 μg to 0.05 μg) value.

NOTES

1 Do not initiate the titration unless and until the background current has stabilized at a low μg value.

2 The coulometric titrator background signal (given as μg H_2O per second) is subtracted from the analyzed result and represents the background moisture presumably accumulated during the time taken to introduce and to titrate the sample. The background value subtracted is the final value read just before sample addition begins. An artificially elevated background value will result in an erroneously low result (i.e. negatively biased). Hence, it is important that the background value be as small (but correct) as possible. Often, it is necessary to physically "swirl" the titration cell as to rinse moisture accumulated on the inner walls into the KF solution. This operation normally speeds up the process of reaching a low background signal.

J-6.12 Ensure that the desiccant tube is clear of obstructions.

J-6.13 Enter the gross cylinder weight (W_1) from **J-6.9** into the moisture meter, if applicable, or record the initial weight of the cylinder to the nearest 0.1 g on a worksheet.

J-6.14 If applicable, remove any prior number displayed for the second weight.

J-6.15 When the moisture meter is stable (maintains a low background current), initiate a run, slowly open the needle valve and introduce sample at a moderate rate such that no foaming is observed on the KF solution surface. Add at a rate such that 15 g to 20 g of the sample is added over an approximate 10 minute period. Use the sample addition count down (delay) if available.

J-6.16 Normally, a 20 g sample is desirable for best accuracy. Observe the cell potential reading or microgram reading. If during sample addition this number climbs rapidly to a comparatively large value (range: 200 to 300), this means the sample contains high moisture, and a smaller than normal sample size (5 g to 10 g) is sufficient.

J-6.17 After the proper sample size has been added, initiate the titration, or after the countdown (delay) period ends the coulometer will begin the titration.

NOTE — If the sample contains high moisture, the rate of titration may never exceed the rate of H2O addition and the titration must be terminated (closing off the needle valve) before too much sample is added. Conversely, if the sample added is small (4 g to 5 g) and the moisture level also is small (5 ppm to 10 ppm), to achieve better accuracy, the sample should be reanalyzed using a longer sample addition delay (10 min for example).

J-6.18 Remove and reweigh the sample cylinder/assembly to the nearest 0.1 g (W_2).

NOTE — If a small sample size is used, a more accurate balance is recommended and weights should be recorded to the nearest 0.01 g.

J-6.19 Enter the weight from **J-6.18** into the moisture meter if applicable, or record the final weight of the cylinder to the nearest 0.1 g on a worksheet.

J-6.20 Calculate and print-out the ppm or microgram water result: Moisture Concentration = Micrograms of H_2O/Grams of sample (W_1-W_2).

Report all results to the nearest 1 ppm. If results are < 2 ppm, report < 2 ppm.

NOTE — Expersience has demonstrated that erratic and out-of-specification moisture results are almost always the result of poor and/or improper sampling. Also, be advised that moisture contamination occurs more readily when the relative humidity is high and particular care is required during these times.

Sample report: Moisture Analyzer Report

No. : 1-14 F=1
CONC: 4.02 ppm
FNo1: (M-B) / (W-w)
M: 83.6 µg
B.G. : 0.08 µg/S
TIME: 5
SENS: 0.10
VA-T: 100
VA-P:
PRNT: 3
CALC: 1
IDNo: 1-14
W: 503.5
W: 482.7
W-w: 20.800000 g
B: 0
TIME: 1:43

J-6.21 Conduct experiment by placing charged filter drier (*max* 80 percent). Ensure to keep it for 24 h after charging, and no leak over the soaking period shall be there, keep it agitated periodically and place it in place of refrigerant cylinder, conduct test and publish data.

ANNEX K

(*Foreword*)

COMMITTEE COMPOSITION

Refrigeration and Air Conditioning Sectional Committee, MED 03

Organization	*Representative(s)*
Indian Institute of Technology, Roorkee	PROF (DR) RAVI KUMAR (**Chairman**)
Annapurna Electronics and Services Ltd, Hyderabad	SHRI G. K. PRASAD SHRI J. S. SASTRY (*Alternate*)
Bureau of Energy Efficiency, New Delhi	SHRI SAMEER PANDITA SHRI KAMRAN SHAIKH (*Alternate*)
Blue Star Ltd, Mumbai	SHRI JITENDRA BHAMBURE SHRI SUNIL JAIN (*Alternate*)
BSH Household Appliances Manufacturing Pvt Ltd, Chennai	SHRI VIJAYA KUMAR LOGANATHAN SHRI ANAND BALASUBRAMANIAN (*Alternate*)
Carrier Aircon Ltd, Gurugram	SHRI BIMAL TANDON SHRI D. BHATTACHARYA (*Alternate*)
Central Power Research Institute, Bengaluru	SHRI A. R. RAVI KUMAR SHRI GUJJALA B. BALARAJA (*Alternate*)
Centre for Science and Environment, New Delhi	SHRI CHANDRA BHUSHAN
Consumer Education and Research Centre, Ahmedabad	MS SWETA MAHAJAN
Danfoss Industries Pvt Ltd, Gurugram	SHRI MADHUR SEHGAL SHRI K. L. NAGAHARI (*Alternate* I) SHRI M. N. S. V. KIRAN KUMAR (*Alternate* II)
Electrical Research and Development Association, Vadodara	SHRI GAUTAM BRAHMBHATT SHRI RAKESH PATEL (*Alternate*)
Emerson Climate Technologies (India) Pvt Ltd, Karad	SHRI CHETHAN THOLPADY SHRI D. P. DESPANDE (*Alternate*)
Godrej & Boyce Manufacturing Company Ltd, Mumbai	SHRI BURZIN J. WADIA SHRI ABHIJIT A. ACHAREKAR (*Alternate*)
Honeywell International India Pvt Ltd, Gurugram	SHRI SUDHIR KAVALATH DR NITIN KARWA (*Alternate*)
Indian Institute of Chemical Engineers, Kolkata	DR D. SATHIYAMOORTHY DR SUDIP K. DAS (*Alternate*)
Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE), New Delhi	DR JYOTIRMAY MATHUR SHRI ASHISH RAKHEJA (*Alternate*)
Ingersoll Rand, Bangaluru	SHRI MITTAKOLA VENKANNA SHRI JEYAPRAKASH GURUSAMY (*Alternate*)
International Copper Association India, Mumbai	SHRI SANJEEV RANJAN SHRI SHANKAR SAPALIGA (*Alternate*)
Intertek India Pvt Ltd, New Delhi	SHRI BALVINDER ARORA SHRI C. M. PATHAK (*Alternate*)
LG Electronics India Pvt Ltd, New Delhi	SHRI ADITYA ANIL SHRI RAJAT SHRIVASTAVA (*Alternate*)
National Thermal Power Corporation, Noida	SHRI D. K. SURYANARAYAN SHRI S. K. JHA (*Alternate*)

Organization	*Representative(s)*
Refrigeration & Airconditioning Manufacturers Association, New Delhi	SHRI GURMEET SINGH SHRI R. K. MEHTA (*Alternate*)
Samsung India Electronics Pvt Ltd, Noida	SHRI GAURAV CHOUDHARY SHRI KALICHARAN SAHU (*Alternate*)
Sierra Aircon Pvt Ltd, Gurugram	SHRI DEVESH MUDGAL
Spirotech Heat Exchanger Pvt Ltd, Bhiwadi	SHRI SUNIL BHARDWAJ SHRI DWIJESH GAUTAM (*Alternate*)
The Chemours India Pvt Ltd, Gurugram	SHRI VIKAS MEHTA SHRI NISHIT SHAH (*Alternate*)
The Energy and Resources Institute, New Delhi	SHRI P. S. CHIDAMBARAM SHRI GIRISH SETHI (*Alternate*)
UL India Pvt Ltd, Bengaluru	SHRI V. MANJUNATH SHRI SATISH KUMAR (*Alternate*)
Voltas Ltd, Mumbai	SHRI SRINIVASU MOTURI SHRI A. D. KUMBHAR (*Alternate*)
Voluntary Organizationn in Interest of Consumer Voice, New Delhi	SHRI H. WADHWA SHRI B. K. MUKHOPADHYAY (*Alternate*)
In personal capacity (*506/2, Kirti Apartments, Mayur Vihar, Phase -1 Extension, Delhi*)	SHRI P. K. MUKHERJEE
In personal capacity (*H.No. 03, Savita Vihar, Delhi*)	SHRI J. K. AGRAWAL
In personal capacity, New Delhi	SHRI S. T. H. FARIDI
BIS Directorate General	SHRI RAJNEESH KHOSLA, SCIENTIST 'E' AND HEAD (MED) [REPRESENTING DIRECTOR GENERAL (*Ex-officio*)]

Member Secretary

MS KHUSHBU JYOTSNA KINDO
SCIENTIST 'C' (MED), BIS

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected